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SCIENTIFIC INTELLIGENCE REPORT

SOVIET RESEARCH ON RADIOLOGICAL SAFETY

CIA/SI 45-59
9 November 1959

CENTRAL INTELLIGENCE AGENCY

OFFICE OF SCIENTIFIC INTELLIGENCE

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Scientific Intelligence Report

SOVIET RESEARCH ON RADIOLOGICAL SAFETY

NOTICE

The conclusions, judgments, and opinions contained in this finished intelligence report are based on extensive scientific intelligence research and represent the final and considered views of the Office of Scientific Intelligence.

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PREFACE

Research on radiological safety is important not only for the protection of persons working immediately with radiation and radioactive substances, but also for others who might either accidentally or by intent be exposed to radiation. In radiological safety, the primary objective is to prevent or minimize exposure of workers and scientists to radiation. Soviet practices in maintaining a radiological safety program have been very lax in the past, a factor which contributed to serious overexposures to radiation. Although the chief subject of this study is the research being carried out by the Soviets on radiological safety, the related topics of current safety practices, radiation disease therapy, and radiobiology are also reviewed.

Extensive background information, consisting of both classified and unclassified publications, has been used in this study. Information as of May 1959 has been included, but later material has been considered.

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FIGURES

SOVIET RESEARCH ON RADIOLOGICAL SAFETY

PROBLEM

To assess the status of Soviet research and practice bearing on radiological safety.

CONCLUSIONS

1. A large-scale, well-balanced program for radiological safety is evident in the Soviet Union at the present time. This program is based mainly on a close scrutiny of Western research, and investigations are directed along similar lines.

2. Many leading medical research institutes are engaged in full- or part-time research on various aspects of radiological safety, and several hundred scientists are connected with the program as research and administrative personnel. Control of radiological safety practices and related research is centralized in two major organizational segments of the Ministry of Health, USSR.

3. The qualitative level of Soviet radiobiological research related to radiological safety, although mediocre at first, has shown marked improvement since 1957, and is now more consistent with the level of U.S. studies on the mechanism of action of radiation, radiogenetics, and the prophylaxis and treatment of radiation disease. The chief difference between Soviet and Western investigations is in the greater emphasis given by the Soviets to the effects of radiation on the central nervous system.

4. The Soviets now subscribe to the internationally recommended levels of radiation exposure, but Soviet safety practices with respect to regulations, dosimetry, monitoring, and radioactive waste disposal are less strict than those of the West. The Soviets have not permitted radiological safety practices to delay priority objectives of their atomic energy program.

5. Future lines of related radiobiological research will rely on the physical sciences to a greater extent. This change in emphasis should enhance investigations on the effects of radiation on sub-cellular particles, nucleic acids, macromolecules, immunogenesis, and cellular functions.

SUMMARY

The Soviets heretofore have not permitted overexposure to radiation to deter them from carrying out research and development in high-priority fields where radiation hazards exist. Nevertheless, in the past 4 years the Soviets have made great progress in raising the level of radiological safety and in pursuing medical research supportive to this end. The Ministry of Health centrally controls Soviet radiological safety practices and related radiobiological investigations through its planning committee, through a Central Committee on Medical Radiology, and through the occupational disease research institutes. Cur-

rently, the Soviets are subscribing officially to the recommendations of the International Commission on Radiation Protection. They apparently are taking pains to enforce good work safety practices within the USSR although there is not yet available to the Soviets a smooth-working, highly trained cadre of health physics personnel. Several years will be required to attain the level of safety practices existing in the West. The Soviets are taking full advantage of openly published Western radiobiological research and are now emphasizing training in radiological safety.

Although the quantity of published Soviet radiobiological research began to increase rapidly in 1955–56, its quality was mediocre until 1957–58 when some progress was made in improving research quality and eliminating the research lag. This improvement, based partially on a close study of Western research, has produced a fairly well-balanced program of research along lines similar to those being pursued in other countries. In radiobiology, the Soviets have given up the attempt to restrict research to Pavlovian methodology and are making progress in other areas such as the mechanism of action of radiation. As recently as early 1958, the Soviets probably were 2 to 3 years behind the West in many of their studies on radiological safety and radiation effects. Currently, however, this is a much more difficult area to judge, and it is more likely that the Soviets now stand in the position of being well conversant with most Western radiobiological research and able to carry out work along similar lines with very little delay.

Published Soviet research on radiation shielding in the biological medical field has been relatively sparse and not particularly imaginative. Soviet equipment useful in radiological safety is often similar to or copied from Western equipment. It is usually not "consumer-designed" but is adequate. The more recent trend has been to enforce stricter rules and regulations in radioactive areas and to follow Western practices as outlined at the Geneva conferences and in other published material. Increasing Soviet interest is being shown in research on dosimetry, shielding, monitoring programs, and waste disposal.

Biophysics has been relatively unimportant in the USSR until recent decisions of the scientific leaders emphasized the great need for a large number of personnel adequately trained in this subject. This is based on the realization of the future importance of biophysics to science. If this new emphasis properly integrates biophysics with present lines of research, the entire Soviet effort should improve greatly. In particular, the Soviets may be expected to increase their contributions in research on subcellular particles, nucleic acids, macromolecules and complexes, immunogenesis, and many cellular functions.

The Soviets have offered little new or useful research in radiation disease prophylaxis and treatment, and their work has been largely repetitive of Western research. More recent information indicates that relatively intense effort is being put into finding chemical compounds useful for prophylaxis against radiation disease although little progress has been made. The Soviets have insisted on the importance of the central nervous system in the pathogenesis of radiation injury, but much of their evidence has not been confirmed in the West. Nevertheless, they have succeeded in demonstrating that the central nervous system is more susceptible to the effects of radiation than was previously supposed. The importance of the central nervous system in the mediation, regulation, and repair of radiation damage cannot be fully assessed at this time, but Soviet data suggest the need for further study by Western investigators.

DISCUSSION

INTRODUCTION

The Soviets have benefited greatly from Western radiobiological research presented at congresses and meetings. At these meetings, the Soviets themselves have presented little new worthwhile information either on re-

search or on radiological safety practices. The Soviets have participated increasingly in international conferences in this field, beginning with the first Geneva Conference on Peaceful Uses of Atomic Energy (1955), which served the useful purpose for the Soviets of emphasizing many of their research gaps. The year 1955 saw a marked upsurge in the quantity of Soviet research material in the fields of radiobiology and radiological safety; and during that year, at least two major Soviet conferences were held on these subjects, possibly to select material to present at Geneva. Taking advantage of Western criticism as well as Western information presented at Geneva in 1955, the Soviets embarked upon a major program of expansion of training of qualified personnel. The Soviets made relatively respectable presentations and contributions during 1958 at the International Radiation Research Congress held in Burlington and again at Geneva, although no significant new data was presented by them. In addition, they have continued their stress on the central nervous system effects of radiation.

An additional facet of Soviet participation at international meetings and UN affairs has been the marked penchant of the Soviets for relating their present actions to political objectives. Thus, many Soviet public statements at these and other meetings have been intended primarily for this effect, and, particularly in technical material, the Soviets have failed to substantiate many of their claims.[1–7]

MAXIMUM PERMISSIBLE DOSE

Officially, the USSR subscribes to a policy of maximum permissible radiation exposure which is at least as low as that of the United States. This official attitude has always been promulgated by the Soviets. Yet, before 1958, the Soviets were quite lax in application of rigid radiation health standards in their nuclear energy research and operations. They relied on practices unacceptable to the West, and their provisions for personnel protection in one of their atomic power plants in 1956 were completely inadequate by U.S. standards. Furthermore, the past record of radiation exposure to personnel puts the Soviets in a very unfavorable light when compared with the U.S. exposure records. Starting some time in 1958, the Soviets have made greater efforts to enforce rigid radiation health standards, and the present official Soviet attitude is that personnel protection is to be considered of paramount importance. This attitude is being enforced by placing health physics or radiation safety personnel (usually medical personnel) in charge of persons working directly with radiation. This change from former practice has resulted in many complaints by Soviet physicists, chemists, and other research workers, voiced particularly at the 1958 Geneva conference, to the effect that stringent radiation safety procedures were hampering the nuclear energy program. These regulations are no more stringent than those in effect in the United States, so it is unlikely that Soviet atomic energy development will be hindered. It seems probable that the Soviets are now making a real effort to comply with the recommendations of the International Commission on Radiation Protection (ICRP).

The thinking of the world scientific community has undergone a gradual evolution so that officially acceptable maximum permissible doses have been revised downward continually since about 1953. Currently, most available printed material on the maximum permissible dose still lists 0.3 roentgen (r) per week as the upper acceptable dose limit. Further, most radiological health units in the United States and in the USSR are still geared to work at the level of 0.3 r per week. Despite this, most Soviets in responsible positions realize, as do Western investigators, that the 1958 recommendations of the ICRP will eventually be accepted as the official dose limit for the countries involved in major uses of nuclear energy.

The latest ICRP recommendations may be summarized as follows: First, the idea of a weekly maximum permissible dose has been dropped in favor of the formula, $D = 5 (N-18)$, where D is the tissue dose in rem,* and N is the age in years. For a person who is occupationally exposed at a constant rate from age 18 years, the formula implies a max-

* rem = roentgen equivalent mammalian.

imum weekly dose of 0.1 rem. The Commission recommended that this value of 0.1 rem per week be used as the maximum value for purposes of planning and design. Within the limitations of the above formula, an occupationally exposed person may accumulate the maximum permissible dose at a rate not in excess of 3 rem during any 13 consecutive weeks although this 3 rem may be received as a single dose. The Commission further recommended that an accidental high exposure of 25 rem or less occurring only once in a lifetime need not disqualify a person from continuing occupation in this field. Doses higher than 25 rem are to be regarded as potentially serious and referred to competent medical authorities for appropriate remedial action and recommendations on subsequent occupational employment. The Commission recommended that for planned emergency exposures* the individual should not receive doses higher than one half the accidental dose of 25 rem stipulated above and subject to the same qualifications. Women of reproductive age shall not be included in planned emergency exposure. All the above figures are for total body exposures and further recommendations are available for limited exposures of various portions of the body.

A group of biologists and geneticists within the Soviet Union is trying to have the official Soviet maximum permissible dose set as low as twice natural background. This is a practically unworkable suggestion from the standpoint of enforcement, measurement, and physical management. A further stipulation of the Soviets is that no pregnant woman is permitted to work where there is any chance of exposure to radiation.[8–28]

Soviet listings of maximum permissible concentrations (MPC) of the various radioisotopes in the body, in water, and in air are essentially similar to those of the Western countries, with a few unimportant exceptions.[16 20–22 25]

* Planned emergency exposure is a term used to denote the planning of action for potential or anticipated emergencies, with emphasis on designating persons who may have to be subjected to doses up to 25 rem.

ADMINISTRATIVE CONTROLS AND REGULATIONS FOR WORK WITH RADIATION

In the past, the Soviets have relied rather extensively on simple administrative and security control where there is a radiation hazard. This practice has often been noted by visitors to be rather inadequate. More recently, the Soviets are augmenting these procedures and following U.S. practices in this field.

The Soviets, despite their statements and avowals to the contrary, have had a history of poor control in radiological safety, as evidenced by statements of persons from other countries observing Soviet practices and by admissions of the Soviets themselves in their various meetings and self-criticism in publications. This poor safety record has been a result of their emphasis on priority development of the atomic energy industry and a lack of personnel trained in radiation hygiene procedures. The Soviets recognize this fully and in the past year have begun to take serious measures to overcome this handicap. This includes establishing departments of radiation hygiene in various medical institutes as well as the planning for a new institute called the Scientific Research Institute of Medical Radiology which is to be built in 1959 near Moscow. Another related facility is the new Institute of Radiation and Physico-Chemical Biology, Academy of Sciences, USSR, with V. A. Engel'gardt as acting director. The first institute is in charge of all Soviet health physics, dosimetry training, and research planning for these fields. The second institute is to emphasize research on radiation genetics and the mechanism of action of radiation. Eventually the additions of training programs and increase in personnel will certainly be felt in the management and enforcement of safe radiation procedures. Apparently the primary responsibility for radiation safety codes of practice in the USSR rests with A. A. Letavet, head of the Scientific Research Institute for Labor Hygiene and Occupational Diseases, Ministry of Health, Moscow.[14] In addition, F. G. Krotkov is in charge of the Central Committee on Medical Radiology of the Ministry of Health. This Central Committee is a powerful coun-

terpart of the U.S. National Commission on Radiation Protection (NCRP). This Committee, Letavet, and the Institutes mentioned are the chief arbiters of Soviet practice in radiological safety. Supportive research is conducted by a large number of investigators in many research institutes. (See appendices A and B.) [8 12 14 15 18 25 26 29–53]

An excellent summary of the Soviet current official position on radiological safety and on the necessary research to be done in this field has been given by F. G. Krotkov.[63]

> With the development of the atomic industry and the adaptation of radioactive elements into different branches of the national economy, science, engineering, medicine, and biology, the number of people subjected to a steady radiation grows from year to year. At the same time the radioactive contamination of the outer medium or environment can increase, as a result of which the population of large cities and of industrial centers and to a smaller extent of farm areas can be subjected to chronic radiation with small doses. Atomic and hydrogen bomb tests play a role in the variation of the natural background of radiation determined by cosmic radiation and the presence of radioactive elements in the earth's crust...
>
> Recently local increases in the natural background have been observed. This circumstance cannot but cause a sense of alarm on the part of hygienists, inasmuch as an increase in the natural background is an immutable proof of radioactive contamination of the outer medium.
>
> The danger of biological action of ionization of radiation is not only in somatic changes but also in genetic action . . . The problem of genetic norms of radiation is, in our days, truly a problem of world significance. Unfortunately, it is necessary to state that we do not possess faultless data for a strict scientific substantiation of genetically allowable doses for radiation. This is indicated by the report of a group of eminent specialists recently published by the World Health Organization . . .
>
> It is difficult as yet to speak about the real extent of danger for humanity and its posterity from changes in the natural background . . . The experimental path for the solution of this problem is difficult and complex because it requires prolonged observations on a large number of laboratory animals with subsequent statistical processing of the resulting data. As regards the observations on people, a very long period of time is required for scientifically substantiated conclusions and generalization . . .
>
> Protection against radioactive contamination of the outer medium assumes special hygienic significance. Inasmuch as the problem of the allowable concentrations of radioactive substances in the outer medium cannot be considered as finally solved it is necessary to strive that radioactive impurities from reactors and other objects of the atomic industry should not enter into the atmospheric air, water and soil. Radioactive wastes which unavoidably form in reactors and in establishments of the radiochemical industry should be collected, stored and removed in such a manner that there would be no contamination of the outer medium . . .
>
> The task of the organs of sanitary control includes the fulfillment of sanitary control of the elimination, storage, and decontamination of radioactive wastes. As a result of the rather incomplete review of the state and prospects of the development of radiation hygiene of this new scientific discipline which was brought to light by the scientific progress of the times, one can separate as the primary tasks the following: 1) systematic observation of the state of the natural background and of its changes as a result of the radioactive contamination of the outer medium on account of the peaceful utilization of atomic energy and tests of nuclear weapons; 2) fulfillment of strict sanitary control of the entry of radioactive impurities into the atmospheric air, soil and water in order to detect the causes of the radioactive contamination of the outer medium and their elimination, if it is a matter of controllable sources of radioactivity; 3)

systematic investigations of foodstuffs, particularly milk and milk products, fish and canned fish, for the content of radioactive substances in general and radiostrontium (Sr^{90}) in particular; 4) participation of hygienists in the development of norms: i.e., in establishing allowable concentrations of radioactive substances in the air, water and foodstuffs; 5) solution of problems of deactivation of water in case of radioactive contamination of water reservoirs; 6) participation in the solution of the problem of elimination and decontamination of radioactive wastes, gaseous, liquid and solid; 7) participation in the development of legislation oriented toward the protection of the population from prolonged action of ionizing radiation as a result of the fallout of the radioactive precipitation, and radioactive contamination of the outer medium; 8) scientific practical solution of problems of utilization of radioactive isotopes in the solution of hygienic tasks.

The Main State Sanitary Inspection of the USSR; the Main Administration of the Militia of the Ministry of Internal Affairs of the USSR; the Division of Labor Protection of the All-Union Central Council of Trade Unions, USSR; and the Ministry of Health, USSR are all intimately concerned with standards for radiological safety.[53]

The standards for arrangement, installation, and use of X-ray equipment in the USSR have been published by the Ministry of Health and are very similar to Western standards.[15] For people working with isotopes and other types of radiation, the rules are quite similar to Western rules, one exception being that all persons working with radioactive substances must undergo special courses of training prescribed for protection against radiation; instruction is supposed to be repeated every six months. All new workers before being accepted must pass a medical examination which is repeated twice a year with a complete blood analysis each time. In addition, Soviet testing procedures here include a neurological examination as a routine part of the medical examination. The criteria of the blood examination are quite specific for an acceptable return to work. These are: a minimum of 60 percent hemoglobin, 3.5 million red blood cells and 5,000 white cells per cubic millimeter. Also, the examination must not disclose disturbances of the endocrine system, or any neurological abnormalities.

Rules and regulations have also been published on levels of radiation for transportation of radioisotopes in the USSR, for working conditions with radioisotopes and for radioisotope laboratories, "hot" laboratories, industrial establishments and other institutes and research establishments using radiation. These standards are practically identical to those of the West.[53]

PROTECTIVE AND DETECTOR EQUIPMENT

The Soviets have developed an excellent total-coverage plastic suit for persons entering highly contaminated areas. These ventilated suits, called pneumo-suit LG–1 or pneumo-suit LG–2, are useful for protection against widespread surface and atmospheric contamination. The suit consists of three basic parts: thin overalls of a special design, a light transparent helmet, and an air supply (a hose with either movable or stationary ventilator). A "Lepestok" respirator is provided for use in cases where only the respiratory passages need protection. This Lepestok portable respirator weighs only 10 grams and is said to be 99.9 percent effective. Western observers have felt that, in general, the Soviet devices, equipment, and techniques for handling isotopes and radiation, ventilation procedures and equipment, air lock devices, safety interlocks, alarm systems, dosimetry systems, and integrating dosimeters have only recently become available and are still relatively crude in comparison with similar Western items. Nevertheless, they seem to be readily available now and will lead to a relatively adequate protection effort. The Soviets have spent much time in devising good equipment for the removal of radioactive particles from laboratory and industrial environments as well as from atomic plant gaseous effluents. A healthy sign of Soviet progress in the field of radiological safety is the emphasis on inspection by their own personnel of the actual operating practices in all types

FIGURE 1. Side view of protective clothing worn by worker when handling radioactive material at Moscow Physical Institute.

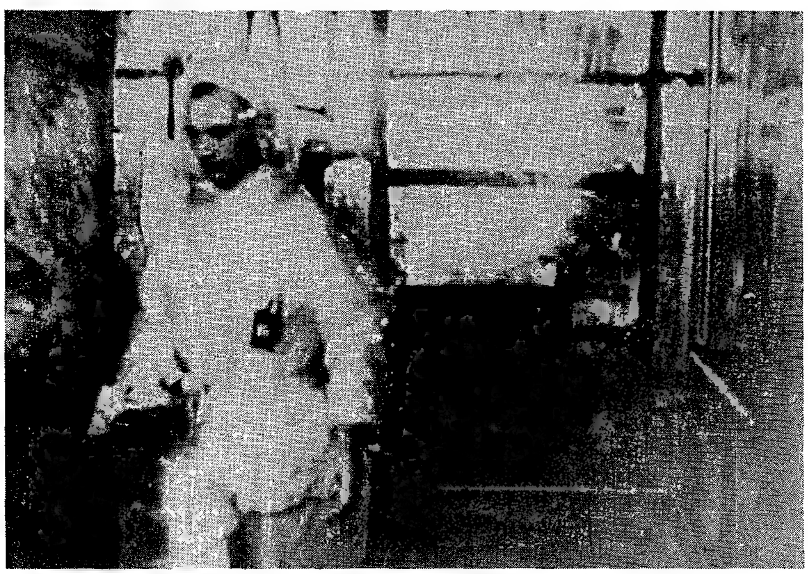

FIGURE 2. Front view of same worker. Note helmet.

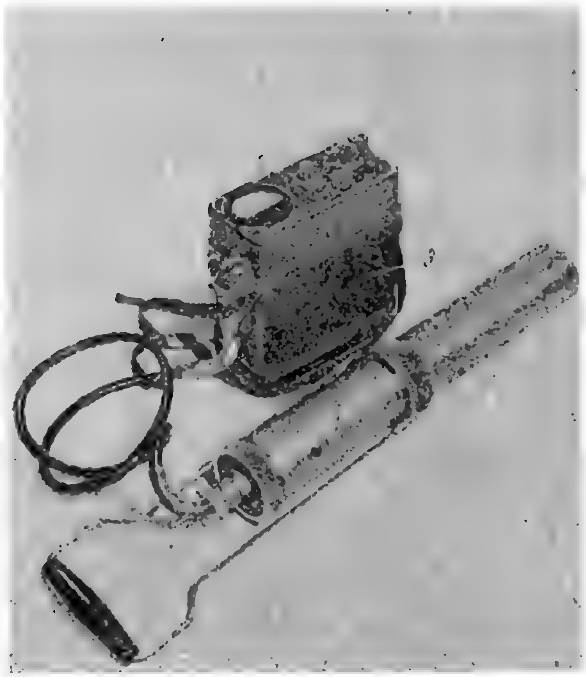

FIGURE 3. SG-42 Gamma-Radiometer with a Scintillation Counter:
1 — case with counter; 2 — control panel
3 — battery supply.

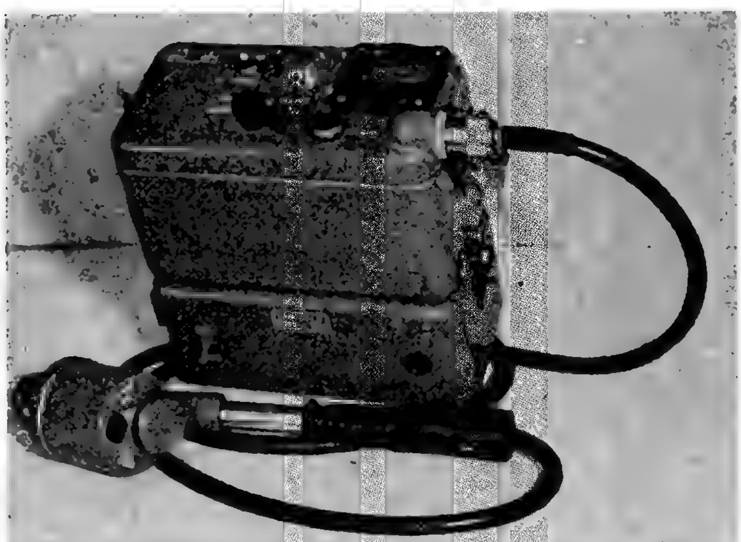

FIGURE 4. Radiation Counter.

of industrial and research establishments using radiation.

The Soviets now have large numbers of various types of instruments for detection, dosimetry, and irradiation. These will not be described in detail since descriptions are easily available and since they match or substitute for equivalent Western items. The instruments include integrating dosimeters, neutron detectors, alpha-beta-gamma dosimeters and detectors, pencil dosimeters, film badges, various types of X- and gamma-roentgenometers, and microroentgenometers, many types of X-ray equipment, cobalt irradiation equipment (so-called cobalt-bombs) and quite recently teletherapy units for cobalt-60, neutron sources, cyclotrons, betatrons, and other much more sophisticated equipment, the latter being most useful for purposes other than medical and radiation safety investigation. Although the Soviets occasionally import therapeutic radiation machines, they have adequate production of their own equipment, and supply machines to other Sov Bloc countries. This high production capability also applies to radioisotopes, which the Soviets freely export. The Soviets have generally followed the West in shielding research and practice. They are well aware of the current types of shielding involving concrete, lead and other metals, multiple interfaces or layers of metals, and boron-impregnated materials which are particularly useful for neutron protection. While they have published on future developments such as nuclear aircraft, their shielding research tends to be conventional, and no major developments seem to be underway at present. [34 56 57 59 71 72 80–82 86 87 93 96 100 101 106]

DOSIMETRY

Only a very few of the top Soviet scientists are particularly capable in this aspect of radiological safety. Much of the published material, even as recently as 1958, still reflects some major misconceptions with respect to dosimetry. Only those persons who have a good physics background seem to have the complete grasp of the principles necessary for good dosimetry. However, one of the results of the 21st Party Congress has been the decision that physicists must contribute to biology and provide adequate support in biophysics and especially in such fields as radiological physics which may lead to better practices in dosimetry. The better Soviet work on dosimetry has followed consistently the lead of Western scientists, particularly British and American. No new ideas have been advanced by the Soviets in this field.[1 14 29 35 48 53–116]

WASTE DISPOSAL, ENVIRONMENTAL MONITORING, AND FALL-OUT

Despite the Soviet public over-emphasis on the dangers of waste disposal and fall-out expressed at the Pugwash Conferences, UN Meetings, and in the Soviet press and radio, most responsible Soviet scientists readily admit privately that the stand of the UN Scientific Committee on Radiation places fall-out and waste disposal in the proper perspective. Soviet published literature and participation at the various international scientific meetings reveal extensive research in the fields of waste disposal, methods of waste disposal, environmental monitoring of particulate and other effluents, aerial sampling techniques and the usual ground or soil, water, flora and fauna sampling techniques. Soviet data are now available on fall-out statistics for strontium-90 at many locations within the USSR, as well as on activities of isotopes in various soil, water, and biological samples. In addition, the Soviets indicate they are conducting relatively detailed studies of environmental radiation backgrounds, including fall-out, as well as contamination by atomic energy installations. Hydrobiological research is underway to evaluate concentrations of radioisotopes from waters and reservoirs by various food chains, plants, and microscopic aquatic organisms. Few data have been published by the Soviets on the higher food chains in such animals as sheep and cattle.[24 76 117–181]

RADIATION DISEASE

Accidental Overexposures

An important part of the medical radiological safety effort has been and continues to be channeled into finding methods, usually chemical, for treating radiation disease, or for preventing the development of radiation dis-

ease after exposure to radiation. While the primary effort in radiological safety should be directed toward prevention of any exposure to radiation, the practical necessities require that the physician be prepared to treat persons exposed to various levels of radiation. The United States in initiating its atomic energy industry laid down various stringent practicable, working rules for handling radiation and radioactive materials. The consequence of this has been that since 1945 up through July 1956 there was a total of 16 radiation accidents in the United States in the atomic energy industry with 59 people overexposed, including two deaths. Since that time, there have been at least two accidents in which six people have been overexposed and one of these has died. For the period from 1 August 1945 to July 1956, the accident rate in the atomic industry was about half the general industry accident rate. For the 9 years ending 1 December 1955, of 200,000 employees, 99.4 percent received less than 5 rem per year (this 5 rem per year is the most recent — 1958 — level suggested by the ICRP as being a safe maximum permissible dose) and only 0.01 percent or 19 people out of the 200,000 received over 15 rem per year.[182]

The above data contrast strongly with Soviet experience in the same field. Excluding estimates of thousands of probable casualties resulting from atomic disasters and accidents with atomic weapons which have occurred in the USSR, over one thousand cases of overexposure of Soviet workers have been reported in published Soviet literature through 1958. This figure (about 1,040) may include some duplication, since the Soviets are very careful to omit any reference to patients' identities, place of exposure, amount and type of exposure, total dose, type of radiation, and outcome of therapeutic procedures. The Soviets give only the types of therapy used and generally indicate that treatment was "successful." Apparently, since about 1957, such overexposures are no longer prevalent in the USSR. In fact, one Soviet physician traveling in the United States felt called upon to make just such a comment.[14, 182–198]

Soviet Objectives

Soviet objectives with respect to radiation disease are: to provide substances for the prevention and therapy of radiation injury; to study the pathogenesis of radiation sickness and to relate changes of immunological processes to pathogenesis; to determine the carcinogenic role of ionizing radiation in tumor development; to intensify work in radiation genetics and the biophysical aspects of radiation biology; and to apply radiobiology to an understanding of fundamental problems of living systems. Because the Soviets have tried so many therapeutic substances for radiation disease on an empirical basis, it is difficult to separate out therapeutic practices from actual clinical research on therapy and prophylaxis of radiation injury. For this reason, we shall consider clinical and laboratory research.

Clinical Aspects

It is well known that whole-body irradiation with X- or gamma-rays can cause radiation sickness and that this can occur in acute or chronic forms, depending upon exposure. Less emphasized are the facts that radiation disease can result from internal or external exposure to alpha or beta rays, from exposure of limited body areas to heavy doses of radiation, or from chronic exposure to lower doses of radiation. Further confusion exists from the failure to differentiate between somatic and genetic effects or to realize that each of these has a short- and a long-term component. The short-term somatic effect of radiation is that clinical entity known as radiation disease, which shows up in various forms depending upon dosage, dose rate and physical condition of the recipient. The short-term genetic effect may consist either of sterility or production of badly damaged but still viable germ cells. The long-term somatic effect may show up in any of several ways, one example being the production of leukemia or the production of a bone tumor from deposited isotopes such as strontium or radium. The long-term genetic effect may be the production of an hereditary deficiency or derangement which may lead either to damage or death in future genera-

tions. These are illustrations of the various possibilities and may help to clarify the various effects of radiation.

The Soviets have described a large number of clinical cases of radiation disease and thus have had sufficient experience with it and sufficient knowledge of Western literature on the subject that they are familiar with the general clinical picture, course and pathology of the disease. The Soviets usually classify radiation disease into four clinical stages: (1) increased functional activity, (2) a latent period in which the stimulation of the first stage is counteracted by, (3) the dystrophic (degenerative) processes, and (4) recovery. Soviet opinion remains divided on the utility of this classification. It seems characteristic of the Soviets that they consider the time between actual irradiation and onset of symptoms as a time in which the central nervous system is being stimulated to produce the subsequent pathological changes in various tissues.

One of the most publicized and characteristic aspects of Soviet work in this field is that of persistent emphasis on the central nervous system (CNS) effects of radiation. While some of the early work published by the Soviets lacked either necessary data or statistical significance, and while the Soviets even as recently as 1958 continued to make public some indefensible statements and claims concerning the role of the central nervous system in radiation disease, recent Soviet work seems to demonstrate conclusively that there are CNS effects at levels far below those widely quoted in Western literature in the past. Further support for this type of effect has been forthcoming from recent U.S. and Western research. It is interesting that during the last few years the tenor of many Russian papers dealing with this problem has changed. It apparently is no longer necessary to relate all physiological research to Pavlovian "nervism" and allusions to the latter are made much less frequently in connection with experiments with radiation pathology than heretofore. Nonetheless, much effort continues to be devoted to clarifying the role of the CNS in radiation disease.

As is true with most of their medical research, the best Soviet work has been done in Moscow, Leningrad, and Kiev in a few institutes such as the Institute of Biophysics of the Academy of Sciences, the Department of Biophysics of Moscow State University, the several institutes of roentgenology, radiology and oncology, the institutes of labor hygiene and occupational diseases, the oncological research institutes and institutes of hematology and blood transfusion. As a matter of fact, the latter type of institute has historically played a very important role in the Soviet clinical treatment program for those persons overexposed to radiation. These institutes, particularly the Moscow institute under A. A. Bagdasarov, were used as the central points for treatment of all Soviet cases of overexposure to radiation. One of the primary reasons for this centralization of treatment was the fact that this institute was the best equipped in the entire Soviet Union to provide the complex necessities required in treating radiation disease. In the last two years or so, there has been a gradual decentralization of treatment into other institutes which are properly equipped and supplied for such therapy. These institutes probably include a few of the military medical institutions.

Prophylaxis of Radiation Injury

Several attempts have been made to show a protective effect by giving less than lethal doses of radiation before irradiation with either lethal or sub-lethal doses. For example, the Soviets have given dogs doses of 3.3, 3.6, 6.6, and 7.3 millimicrocuries of cobalt-60 per kg. body weight. This pretreatment seemed to protect some dogs from absolute lethal doses of X-ray; the investigator postulated an immune reaction effect. This work is interesting and should be pursued further since the data must be considered preliminary. Other studies on the use of irradiation to protect against subsequent irradiation have given equivocal results. While several Soviet investigators have claimed a stimulating effect from low doses of radiation, the general tendency in the USSR and in the West is to consider that all radiation produces adverse effects and that there is no adaptation

to radiation. It is now recognized in the West that research of this type must be carried out under rather rigorously pre-determined conditions and the criteria for prophylactic effect must lend themselves to reproducible study. The Soviets have not yet reached this point in their published research on prophylactic agents and this inadequacy is compounded by their shortcomings in statistical control and analysis of experiments. Only in 1958 and 1959 have the Soviets evinced interest in the need for such control and for uniformly reproducible experiments. Thus, to a large extent the research discussed below is less meaningful than it should be, because the criteria of prophylactic effect are sometimes influenced by the investigator's failure to provide adequate control studies.[199-201]

For general body prophylactic protection against irradiation, the Soviets have investigated such ideas as the state of nutrition prior to irradiation, the general physical condition of the test subject, hypoxia, hypothermia and a long list of various chemical substances which have been tried, usually on an empirical basis. The pre-irradiation use of blood or blood products as well as shielding of various portions of the body have also been studied. Hypoxia produced by lowered barometric pressure, by chemicals such as cyanide or by shifting the composition of inhaled air, or by hypothermia, and even by natural hibernation, has been demonstrated to prolong the life span of irradiated animals if it occurs before irradiation. However, claims concerning the absolute protective effect, that is, a decrease in overall mortality rate, have been much less well-substantiated. These prophylactic techniques, if given after irradiation, almost uniformly worsen the radiation effect. Shielding of various portions of the body has often produced a good measure of protection against irradiation. This technique has shown that the body increases its production of erythropoietin which stimulates the production of red blood cells and may prevent post-irradiation anemia. So far, this technique has not proved particularly useful clinically in radiation disease. The use of blood or blood products such as packed erythrocytes, thrombocytes or white blood cells has been claimed to produce beneficial results but the data are insufficient to substantiate this claim. Some Soviets have suggested that ethanol offers protection against radiation, however, others have found, as have Western investigators, that ethanol actually increases the ill effects of radiation. The general consensus of the Soviets is that some anesthetics and narcotics, if given before irradiation, may have some protective effect, particularly nembutal, amytal and ether. If given afterward, these agents did not offer protection or therapy, but seemed to worsen the damage. Soviet investigators indicate that hedonal, urethan, and phenamine probably do not offer a protective effect at any time. Morphine, nembutal and ether may provide some degree of prophylaxis. This effect is assumed to be at least partially an hypoxic one. Novocain has also been claimed to show a significant prophylactic action.

About eighty substances have been reported by the Soviets to have some prophylactic effect against irradiation. These are listed in appendix C. Of all these substances probably the most effective has been cysteineamine (also known in the USSR as mercamine, becaptan, or betamercaptoethylamine). However, certain Soviet studies have shown that quite possibly this compound produces tumors in mammals. Many other compounds have been tested and found to be unsatisfactory. Current Soviet testing, particularly under N. V. Luchnik and S. Ya. Arbuzov, represents a major screening program for compounds providing a protective effect. Luchnik and his co-workers seem to have reasonable and reproducible experimental techniques for determining the protective effect of compounds upon irradiation damage. Luchnik has suggested that his data show there are different mortality peaks which vary according to the radiation dose and which apparently reflect death from different causes. He believes that different protective agents which act on these separate causes of death may change the mortality peak. This is consistent with U.S. views regarding the three major types of radiation death: the gastrointestinal, the hematological, and the CNS deaths. Protection of the skin from radia-

tion damage has received considerable attention both here and in the USSR, because it is of such importance to the therapeutic uses of radiation. Some Soviets have claimed good skin protection with such agents as stickleback fat, decomposed butter, fish oils, vitamin-containing ointments, methionine ointment, naphthalan oil, plasters, Shostakovskiy balm, aloe emulsion, tezan emulsion, methylated derivatives of certain fatty acids, novocain block, and tissue therapy a la Filatov.* Their Ointment No. 2 is an aloe emulsion and the Ointment No. 4–U is methylated linolenic acid. Of these, the aloe and tezan emulsion offered some protection, the latter being somewhat better, especially if used repeatedly before every exposure to radiation. The newer work on methylated derivatives of fatty acids is promising but only preliminary. 8 202–232

Soviet research on prophylaxis for internally deposited radioisotopes is practically nonexistent. Some attention has been directed toward the therapeutic removal of radioisotopes and toward good working rules and habits in preventing deposition of isotopes.

Treatment of Radiation Disease

Despite press and radio claims of successes in treating radiation disease, Soviet scientific descriptions of the treatments reveal that they follow Western suggestions for therapy, with more emphasis on blood transfusions. The Soviets, although emphasizing immediately practical therapeutic and prophylactic measures using chemical compounds, are aware that the long-term approach to a rational therapy or prevention of radiation disease is through detailed knowledge of the mechanism of action of radiation. Thus, the Soviets publish actively in both these fields and keep abreast of Western developments.

Soviet work on the therapeutic removal of radioisotopes from the body has been relatively scanty and only recently have articles begun to be published on some of the newer methods of therapy such as chelating agents. The investigators responsible for most of this current activity are those in the Moscow Institute of Labor Hygiene and Occupational Diseases under A. A. Letavet, Ye. B. Kurlyandskaya and Yu. I. Moskalev. Much of this material is repetitive of research that has appeared previously in the West. The compounds investigated include ethylenediaminetetracetic acid (EDTA), hydroxyapatite with disodium phosphate, hexametaphosphate (this compound is extremely toxic), sulfosalicylic acid, aurintricarboxylic acid euphylline (theophyllinethylenediamine), orthophenylenediamine, yatren (5-sulfonic-7-oxyquinoline), cincophen and some miscellaneous materials such as parathyroid hormone and liver extract. Some of the compounds mentioned recently in U.S. literature seem not to have been investigated as yet by the Soviets; these include rhodizonic acid, DTPA (diethylenetriamine pentaacetic acid) and BAETA (2, 2′-bis-[di-(carboxymethyl) aminodiethyl ether]).[233–240]

Other therapeutic measures against radiation disease include the following:

a) hygienic supportive measures such as rest, graded exercise, fresh air, high-quality and high-calorie diet, or if necessary, parenteral diet, and vitamins such as thiamine, riboflavin, pyridoxal, niacin, cobalamine, citrin, rutin, vitamins C and K, and para-aminobenzoic acid. Citrin and rutin (not considered vitamins in the West) are suggested by the Soviets as blood capillary strengthening "vitamins."

b) for replacement of blood loss or for anemia or other types of blood destruction the Soviets have investigated whole blood, blood serum, polyglukin, sinkol', polyvinylpyrrolidone, and parenteral solutions such as TsOLIPK–5, and LIPK–43, hydrolysin (L–103), aminopeptide-2, such blood products as red cell mass, white cell mass, and thrombocyte mass, hemoglobin preparations of various sorts, "colloidal infusion," bone marrow,

* Tissue therapy was originated in 1933 by Academician V. P. Filatov who died in 1956. Tissue therapy is based on the therapeutic application of tissue kept in a state of "survival." These are conditions of a delayed and lowered vitality. The idea of the therapeutic properties of these stored tissues suggested itself in Filatov's work on corneal opacities. The acual therapeutic value of this entire method has never been adequately documented.

cobalt ion and calcium ion and properdin, as well as the cattle blood products BK–8, LSB, and ACS. The latter two have been withdrawn from production and distribution. The BK–8 is a product prepared by V. A. Belitser and K. I. Kotkova. Another Soviet study indicated that use of packed red cells or blood transfusions is not desirable, and in fact may be dangerous from the 5th through the 15th day of radiation disease. Other substances found useful for anemia include iron preparations, liver preparations, kampolon, antianemin, niacin, cobalamine, pyridoxal, vitamin C, folic acid, hepatocrine. Therapy for the leukocytopenia, or decrease in white cells, resulting from radiation disease, has been the subject of much Soviet study with various conflicting results. Some Soviets suggest that bone marrow stimulants such as pentoxyl, sodium nucleinate, metacyl, leucogen and tezan-25 are not useful after the irradiation. U.S. workers have not had good results with this type of agent. Others suggest that these agents should be used immediately, while most of the Soviets suggest that the agents should be used later when the marrow is able to respond to stimulation. In addition the Soviets have used liver preparations, vitamins, and the tissue therapy method of Filatov with such preserved tissues as skin, umbilical cord, and eye, and have claimed beneficial therapeutic effects not only for the leukocytopenia but also for the general body response.

c) control of infections and toxemias is accomplished by means of antibiotics, tissue therapy, properdin and, where necessary, antitoxins and vaccines. Some Soviets have suggested that penicillin, biomycin (chlortetracycline or aureomycin), levomycetin (D-chloramphenicol), streptomycin, and ekmoline (a triprotamine fish tissue extract) have useful properties in treating infections during the period of radiation disease. However, more recently some Soviets reported that biomycin may be toxic after irradiation and that streptomycin is probably the most useful single broad-spectrum antibiotic, with penicillin next best. U.S. data indicate that streptomycin is best, and that chlortetracycline and terramycin (oxytetracycline) are somewhat helpful particularly if given with streptomycin. Other U.S. data indicate that penicillin, neomycin, polymyxin and certain other antibiotics are not useful in radiation disease.

d) management of radiation-induced nausea and vomiting has been investigated using bromides, diphenhydramine, urotropin, cysteineamine, cysteineamine salicylate, cysteineamine chloride, menthol, valerian, novocain, camphor, sodium hyposulfite, dimedrol, caffein, barbiturates, aminazine (chloropromazine). Some Soviet data have suggested that anesthetics of various sorts, novocain, hypothermia, barbiturates, ethanol, and other narcotics and CNS depressants will aggravate radiation disease.

e) repair and prevention of skin damage has been attempted with aloe emulsions, stickleback oil, fish oils, vitamins, methionine ointment, tissue therapy, Shostakovskiy balm, novocain block, tezan-25 ointment, fibrin film, penicillin ointments, and ointments of the methyl esters of such fatty acids as oleic, linoleic, and linolenic, the latter preparations being called linol and linolen.* Apparently the most effective of these are the linolen ointment and the methionine ointment.

f) supportive therapeutic substances have included zymosan, yeast extracts, hormones, such as synesterol, diethylstilbestrol, somatotropic hormone, adrenotropic hormone, calcium ion, calcium gluconate, sodium hyposulfate, sodium chlorophyllin, yeast, tissue therapy, calcium glycerophosphate, caffein, amphetamine, phytin, phosphren, lipocerebrin, pantocrine (powdered reindeer horn), ginseng and ginseng extracts, extracts of Schizandra chinensis, plus hyaluronic acid-protein complexes prepared from the lens of the bovine eyeball. A few others have been suggested as having some therapeutic effect but this has not been shown adequately. These include metrazol, phenatine (benzedrine plus niacin), strychnine, adenosine triphosphate (ATP), cervical vagosympathetic novocain block, glycogen and insulin, casein, saccharose, and many parenteral solutions.[8 27 189 195 202 204 205 208 213–215 219 222–224 226–232 241–287]

* Linolen is the methyl ester of linoleic acid and linol is a mixture of the methyl esters of oleic and linoleic acids.

General comments concerning the above research seem appropriate here. First, the Soviet tendency is to make invidious comparisons of their work with previous work published by scientists of other countries, particularly from the United States. This is especially true for those articles dealing with therapeutic management of patients who have received radiation either for treatment or from industrial overexposure. The second major point is the lack of any adequate standard of judgment concerning the therapeutic effect of many of the agents used. Quite often the primary and almost sole judgment as to whether or not an agent is effective in treating radiation disease is a simple statement to the effect that this substance was found to be effective or found to give a beneficial effect. Most of their judgments are qualitative in nature rather than objectively judged against some reasonably described and acceptable standard. This may result partially from the Soviet lack of background in statistical analysis. Finally, we ought at least to compare some of the methods and therapeutic agents used with those used in Western countries, including the United States. Those measures which are considered to provide a generalized improvement, e.g., adequate diet and fluids including the proper use of vitamins and food supplements, plus antibiotics, blood replacement where necessary, hormones, anti-nausea or anti-motion sickness drugs, and tranquilizers are all widely recognized as useful. One can take issue, however, with the Soviet use of some of their products such as BK-8, LSB, tissue therapy, pantocrine, ginseng, Schizandra chinensis, camphor and other similar proprietary measures. Investigators in the West have also used a large number of therapeutic agents, but have noted that dubious therapeutic agents which may harm even normal or healthy persons are even more questionable for treatment of radiation disease. There are signs that the Ministry of Health and its organizations are making attempts to combat the use of unproven and perhaps dangerous therapeutic agents. There has been a noticeable withdrawal from production of several therapeutic agents in the USSR. The most recent example is LSB which was withdrawn from production in March 1959.

RADIOBIOLOGY

General

Supportive to the program of radiological safety in any country is basic research in associated areas of radiobiology. It is here that the mechanism of action of radiation is studied with the hope that eventually some rational adequate therapy might be developed for radiation disease. Radiobiology includes research on toxicology, absorption, excretion and forced excretion of many of the radioisotopes which have become important in recent years as a result of atomic energy developments. It also includes research directed toward understanding the extent and nature of background radiation, the extent of build-up of radiation or radioactive isotopes from uses of atomic energy, the potential genetic and somatic dangers of the gradual increase of radiation to the human population, and other topics of a like nature. Without adequate radiobiological research there could be no long-term program for progress in radiological safety. An area currently receiving attention and of major import to radiological safety is that of the relative biological effectiveness of various types of radiation. The Soviets are insistent that the central nervous system is extremely important in any body reaction to irradiation. While many of the claims advanced by the Soviets in this field are lacking in support and are presently questionable, it seems quite certain that there are definite central nervous effects from irradiation, perhaps more than was thought previously in the West.

Radiogenetics

Basic Soviet research in genetics received a major setback during the period of rigid Lysenkoism. However, since that time there has been a gradual resurgence of classically oriented geneticists in the USSR, primarily into the field of "radiation genetics," a Soviet euphemism for the study of modern genetics. During this resurgence of classical geneticists, Lysenko himself has retained his position as head of the Institute of Genetics with the

result that the classical geneticists have been required to work in other institutes, with major support for classical genetics most recently coming from biochemists and biophysicists. For example, the Institute of Biophysics, Academy of Sciences, has for the last three to four years supported the classical geneticist N. P. Dubinin and some of his followers. In addition, such people as V. A. Engel'gardt have been lending major support in the Academy of Sciences to various classical geneticists. One of these, Timofeyev-Resovskiy, has been working in the Institute of Biology, the Ural Affiliate of the Academy of Sciences in Sverdlovsk. Dubinin has supported work by other geneticists and has begun major research in the new "science city" near Novosibirsk where he was selected to head the new Institute of Cytology and Genetics. However, he has more recently been criticised by Pravda. Information presently indicates that he has been spending about half his time at that new location, the remainder of his time being spent at Sukhumi, the primate research colony, and in the Institute of Biophysics, Academy of Sciences, in Moscow. The most recent support for the "classical geneticists" in the USSR has come from the physicists who would like to see established an adequate physical basis for genetics research and for handling genetic information. Thus, it seems possible that, while Lysenko will retain his position at the Institute of Genetics, the basic research in genetics in the USSR will be conducted under the heading "radiation genetics" and will be of a more conventional nature.

The importance of genetics research in radiobiology has been emphasized by the recent discussions concerning the long-term hazards of fallout and the gradual increase in background radiation now occurring on the surface of the earth.* There is evidence that the Soviets are now beginning a long-term primate genetic research program with low doses of radiation. One Soviet Geneva paper did present some data on primate genetics but the research was carried out with a small number (7) of monkeys, and the results are inconclusive. Other Soviet studies in radiation genetics are being carried out on microorganisms as well as on mammals. If sufficient priority is attached to the long-term primate genetic studies the Soviets may well regain some of the ground lost in the field of genetics.[24 288-328]

* There is presently no answer as to whether there is a threshold, that is, some point before which radiation has no effect on genetics, or a linear response to radiation, that is, all radiation in addition to the natural radiation background is harmful. Discovery of a definite threshold effect either in mice or in primates does not mean that such findings can be extrapolated directly to man. Nevertheless, in the absence of human data, such a discovery would be used as a tentative yardstick in estimating future hazard of fallout.

Mechanism of Action of Radiation

Research in this field supports the most important long-term possibilities for understanding the nature of radiation and its action upon the body, with the hope that a rational explanation of the action will lead to a rational method for therapy, or prevention of radiation disease. A good share of the work on mechanism of action on radiation is potentially useful for early detection tests of radiation damage. Thus, as research proceeds further toward actual delineation of the minute cellular or sub-cellular process occurring immediately after irradiation, the investigators acquire not only knowledge concerning the mechanism but also methods for early detection of changes induced by radiation. We shall consider two major aspects of the mechanism of action of radiation. First are the primary physical and biophysical processes involved in the absorption of energy from radiation or radioactive particles. Second are the subsequent tissue, cellular, chemical and other changes within the organism.

The initial absorption of energy by a living organism may be direct or indirect. The sequence of events and the direct and indirect effects are described in a 1958 report of the United Nations Scientific Committee on the Effects of Atomic Radiation.[24] The target theory, first proposed by Lea, served to focus initial early research attention on the primary process of ionization and a direct effect of radiation on the cell. The next major step was the recognition of the presence of an indirect effect in which the microstructures need not be hit directly by an ionizing particle.

These indirect effects are apparently mediated by the action of radiation on water, the primary solvent in biological systems. Additional indirect effects may result from the action of radiation on other chemicals within the cell. A further direct action of radiation, besides that of ionization of a "radiosensitive target," is that of excitation of the orbital electrons of substances within the cell.

No single mechanism can be the basis of action of all forms of radiation injury, since a cell is a highly organized system with a diverse constitution and structure among its parts. In any event, it should be recognized that the physical chemical processes developing as a result of the direct action of the ionizing radiation are the most important but only the initial link in the long chain of pathogenic mechanisms which lead to radiation disease. An important role is subsequently played by the response reactions of the organism. Soviet research in general recognizes the above concepts and subscribes to them.

More recent Soviet research has included investigations of the mechanism of action of some antimitotic chemicals such as the chlorethylamines. Some Soviets consider that the mechanisms of action for these chemicals are similar or identical to that for radiation, while other Soviets and most Westerners consider that there are some distinct differences. Another interesting area of research started primarily by the Soviets and now arousing interest elsewhere is the study of electronic paramagnetic resonance of irradiated materials. While this research is in its early phases, it could lead to interesting discoveries as to the details of biophysical processes involved in energy absorption in tissues. Other Soviet research has included studies on cellular adaptation to irradiation (apparently there is none), studies of the oxidative production of toxins in tissues, and an interesting concept by V. A. Engel'gardt given at Geneva concerning a multiplying chain mechanism to explain the extensive effects of ionizing radiation from the small energy input.[24 27 241 329–347]

One of the major facets of the Soviet research effort in radiobiology is the continued, insistent emphasis upon the role of the central nervous system in producing actual radiation damage. Several years ago, the predominant Soviet attitude was that the central nervous system was responsible for the mediation of all radiation biological effects. Currently, the Soviets still emphasize that the central nervous system plays a dominant role in production of effects within the body but the real emphasis is on the nervous system's integrative role. Another claim by the Soviets has been that radiation in small doses will produce beneficial stimulation, that minute amounts of radiation may even be necessary for life. Most Soviets now recognize that such a claim arose from mistaken interpretations of stimulation produced by the action of low doses of radiation on microorganisms. They now realize that this reaction is a definite early sign of radiation damage, a sort of phasic response to stress and seems to support their claim of no threshold response to radiation. Soviet work on paramecia also has suggested that there is no threshold for radiation damage. In general, there is little good evidence one way or the other for a threshold effect. Theoretical consideration of the mechanism of action of radiation led one Soviet, A. V. Lebedinskiy, to suggest that the so-called "sigmoidal response curve" does not imply a threshold of response to radiation but rather demonstrates a summation of reparable and irreparable components of radiation injury. Since there is "always" an irreparable somatic component there is no such thing as a threshold, he concluded. A further portion of this assumption is that as a total dose increases the reparable fraction decreases. The evidence of a direct relationship between dose and damage at very low doses is still unsatisfactory. There has been considerable Western and Soviet research on the changes of macromolecules such as proteins, enzymes or nucleic acids after irradiation. Some Soviets have suggested that irradiation produces an immediate, non-specific shock reaction from protein denaturation, with specific suppression of functions of adaptation but maintenance of basic vital functions. The specific suppression of function is assumed to be hereditary, and is believed to be responsible for

the later effects of radiation. This research is interesting and may prove fruitful for a better understanding of how the actual tissue effects of biological damage from radiation are produced.

Other Soviet research is concerned with the possibility that the primary absorption of energy by the tissues occurs in macromolecules and that there is a direct effect from depolymerization of the macromolecules and an indirect effect from the resultant production of radiolysins. The evidence presented by the Soviets, like that of Western investigators, seems to show conclusively that nucleic acid metabolism, for instance, is affected by irradiation. The phosphorus turnover in nucleic acid is suppressed by irradiation of normal or tumorous tissue. The enzyme ribonuclease is inhibited and the conversion of ribonucleic acid (RNA) to deoxyribonucleic acid (DNA) is upset. The depolymerization of nucleic acids also seems to bear some direct relationship to the degree of radiosensitivity of tissue. Apparently some radioresistance of nucleic acids is related to the strength of the protein-nucleic acid bond. In normal tissue, this bond is quite strong and radioresistance is relatively high. In tumorous tissues, this bond is easily split and the tissue is therefore more sensitive to irradiation.

There are good Soviet data indicating the operation of humoral and toxic factors in irradiation leukopenia, red blood cell hemolysis and depression of mitosis in implanted tumor cells. The red cell hemolytic factor was thought to be an unsaturated fatty acid and it was suggested that the production of this factor was closely related to radiation injury. Although the results were tentative, the work on inhibition of mitosis seemed to indicate that irradiation of the head produced a reflex stimulation of adrenalin which provided the mitotic depression. Also receiving attention is the radiosensitivity of resting tissues as compared with that of mitotically active tissues. The fact that active tissues are more radiosensitive would seem to be related to cell division and the state of nucleoproteins but the exact mechanism is still not known. Soviet and Western work seems to indicate rather conclusively that alteration of the phosphorylative processes, the oxidative metabolic processes, and high energy metabolism are affected by the irradiation process, but are not the source of the major part of the tissue damage resulting from irradiation. One major test that the Soviets are currently using for early detection of radiation damage involves the fluorescence of tissues within periods of a half hour or so after irradiation with doses as low as 25 r for mice. The group developing this technique patterned after earlier U.S. work, is that of M. N. Meysel'. This work has been done in microorganisms as well as in mammals and the finding of fluorescence (using an acridine dye) of irradiated tissues after about a half hour is relatively consistent and seems to arise from the degradation products of macromolecules such as DNA, RNA, or nucleoprotein complexes. There is also a Soviet report on the effects of radiation on nucleic acid metabolism and nucleic acid content of various tissues.

Although a good deal of emphasis in the past has been given by Soviet investigators to the study of whole-body reactions, that is, whole animal organisms as opposed to studies on isolated or model systems, a relatively recent trend has been the increasing use of models and isolated systems by the Soviets. Some of this work was summed up at Geneva by G. M. Frank, *et al.* Frank suggested that the study of radiation action phenomena may be accomplished with models first, and then with a gradually increasing approach to the total organism. He feels that a number of biological reactions hitherto considered peculiar to an entire organism can be reproduced *in vitro* in isolated tissues. An example is irradiation-induced diminution of elasticity of large blood vessels which he obtained when irradiating either the entire animal or an isolated blood vessel. Another method for study which he considers even more promising but also more difficult and requiring much better training in the physical sciences is the study of physical-chemical changes in the tissue of the entire living organism. Western investigators have found such approaches very useful in recent years.[10 24 33 73 188 231 250 329 333–334 336–337 341 345 348–374]

Radiosensitivity and the Central Nervous System

Sensitivity of different types of tissue to radiation constitutes a topic on which there are major disagreements between Soviet and Western investigators. In the past the Soviets have made attempts to demonstrate that the central nervous system is the most radiosensitive of all tissues. Failing to present concrete, adequate data to support this thesis, the more recent Soviet trend is to implicate the central nervous system in the mediation of the radiation effect. The Soviets consistently emphasize the role of the central nervous system as an integrating unit in determining the locus and the extent of radiation reaction, as well as the nature and type of recovery. Two lines of research in which central nervous system effects are considered most important are studies on radiosensitivity of young organisms and research on the variation of radiation response with changes in the phylogenetic scale. The Soviets have suggested the use of physiological tests of smell, taste, balance, sight and touch for determining slight radiation damage. These suggestions follow naturally from the Soviet tendency to use reflex techniques in determining physiological status and from their bent for insisting on the greater sensitivity of functional tests as opposed to morphological tests. There is, however, not complete unanimity among the Soviets concerning the central nervous system's sensitivity to radiation. Many subscribe unquestioningly to the fact that the most sensitive tissues to radiation are those of the hemopoietic system, followed by those of the gastrointestinal tract. This parallels Western findings. An example of Soviet research on the CNS is contained in an article by A. M. Kuzin, of the Institute of Biophysics in Moscow, in the January 1958 issue of a U.S. journal. Kuzin emphasized CNS changes after irradiation (carried out at 50 to 100 r) and suggested that electroencephalographic changes were noted with 1 roentgen (an unfounded claim actually made on the basis of straight-line extrapolation). Further studies of CNS damage from irradiation demonstrate conclusively that doses of the order of 50 r will produce definite measurable CNS reflex changes, but no coherent quantitative picture is yet available.

Other types of research on CNS response to radiation include studies on interoceptive reflexes, conditional reflexes, light-eye reflexes, and flexor reflexes. The Soviets suggest that reflex changes indicate damage in the diencephalon and reticular substance. So far as is known, no equivalent work is underway in the U.S. Interestingly enough, most of this research of the Soviets shows quite good work at levels of 100 r or greater but poor, inadequately controlled work at levels below this, with unjustified extrapolation from studies at the high dose levels to "expected" changes at very low dose levels. It is the unjustified extrapolation to which most Western investigators object strenuously. This point was particularly noticeable in the Soviet presentations at the latest Geneva Conference on Peaceful Uses of Atomic Energy. But it has also been true of many papers in the 1956–57, and –58 period. More recent Soviet works show more reserve about making unjustifiable conclusions, and instead, give good simple presentations of the data observed.

The Soviets have studied many patients irradiated therapeutically and have taken many EEG tracings. Their conclusions are that the initial EEG reaction to irradiation represents an increased cortical activity within about 10 minutes and a subsequent variable amount of cortical inhibition and later normalization of activity. A typical kind of conclusion or inference drawn by the Soviets is that the data indicate that during acute radiation disease, disturbances in the activity of the vitally important systems leading to lethal outcome, are caused by the disturbance of the regulatory function of the central nervous system.

The Soviets often use irradiation for therapy of conditions which they feel are a result of CNS changes but which Western clinicians consider essentially unrelated to the CNS. Thus, 30 patients with frostbite of fingers,

toes, wrists, hands, feet, and knee joints were treated with irradiation with what were called good results. The author concluded by saying that these results "proved both local and general favorable effects of X-ray therapy on disturbed blood circulation in injured tissue by alleviating blood vessel spasms, by improving trophic activities, and regulating fundamental nerve processes." This use of irradiation is, at best, ineffective. Other research involving CNS effects includes investigation of olfactory sensations, studies of the ultra-slow rhythms of the electrical potential of the brain, changes in the electrical resistance, capacitance, and impedance of the CNS, and morphological investigations of the central nervous system. Even in conditional reflex research it is notable that there is no unanimity among Soviet authors or investigators as to (i) whether irradiation produces an initial increase or decrease of a positive conditional response, (ii) the duration of such alterations in various animals and (iii) numerous other subtle phenomena. In the case of bioelectric phenomena, 500 to 1,000 r seems to have a distinctive effect on the bioelectric activity of the cerebral cortex and also on peripheral nerve action currents and the reactivity of internal receptors.

In summary, it is difficult to reach a definite conclusion as to any CNS radiation effect threshold that has been established experimentally by the Soviets. They have called attention to the fact that the central nervous system can be damaged by doses of radiation at lower levels than was previously supposed in the West. These results have also stimulated Western work along these lines, and in 1958 and 1959, a very small beginning was made in the U.S. toward research of a similar nature. An indication that even the Soviets are not completely convinced about very low dose changes in the CNS was given by Lebedinskiy when he said that contrary to material appearing in print and contrary to other claims by other Soviets, the CNS changes were used only experimentally, not in industry to detect radiation damage in persons potentially exposed to radiation. The following omissions are present in a substantial part of the published reports: (1) Lack of statistical analysis of results; (2) inadequate discussion of instrumentation and dosimetry, particularly as to depth dose; (3) limited use of controls; (4) little information on the general conditions of animals after a given irradiation; (5) limited presentation of experimental data; (6) failure to report negative experiments. On the other hand, the Soviets have certainly obtained a number of results which, if confirmed, will be of the greatest theoretical and practical interest. Among the major findings are: (1) Evidence that there may be a pathologically increased afferent flow to the CNS contributing to early and late pathology and that treatment should be directed toward this phenomena. (2) Indications that functionally the CNS is very sensitive to radiation. Many of the findings reported above could be interpreted as resulting from small random disturbances in a variety of cortical networks and possibly all parts of the CNS, including peripheral receptors. The variability in quality of Soviet published work is much greater than in the United States. There is probably no single Soviet investigator who has not at one time or another published some work in which either the data or the conclusions are unacceptable by Western standards.[24 195 202 231 245 272 288 339 344 364 375–401]

Additional Soviet research on radiation effects on the body has been done in experimental animals. Clinical observations have been made on patients exposed to therapeutic radiation and to accidental radiation overexposures. These include determining the effects of radiation and deposited radioisotopes in bone, for short-term and long-term exposures. Studies have also been done on the other systems of the body i.e., the cardiovascular system, the hemopoietic system, the endocrine system, as well as individual organs and tissues. Much of this work is similar to U.S. research. The publication and research effort has been expanding so rapidly in the last two to three years in the USSR that the Soviets are now in a position to begin making major contributions in this field and to initiate original lines of research.[24 27 184 188 231 236 244 262 263 272 278 288 334 335 338 339 344 345 365 371 378 397 402–476]

Immunological Response to Radiation

Another area in which radiation effects are very important is that of the immunological responses of the body. Although Soviet research lags substantially behind that of the United States, some Soviet findings are of interest. Irradiation and infection act synergistically in weakening body defenses. Apparently even under the stress of one insult the body tries to respond to the second, but in so doing loses ground against the initial insult. Another action of radiation is to suppress the body's natural defenses or immunity against many pathogenic organisms. A decrease in natural immunity often leads to autoinfection. This infection is undoubtedly a serious complication of radiation disease, but is not responsible for the major pathology of radiation disease as has been suggested by a few Soviet research workers. Some of the diseases which have been found to occur more readily after irradiation are: influenza, whooping cough, diphtheria, paratyphoid, leptospirosis, colon bacillus infections, and various anaerobic infections. One Soviet investigator suggested that the technique of lowering disease resistance by irradiation of animals be used as a laboratory procedure for infectious disease research. Another worker described an increase of natural immunity (measured by an increase in complement-fixing activity) after irradiation of rabbits with ultraviolet rays. This seems rather unusual and needs further confirmation and study. In addition to depressing natural immunity, irradiation seems to increase body sensitivity to bacterial toxins. This may be one reason for the observations that infections are more severe in the presence of radiation disease. However, one Soviet investigator claims that irradiation has no effect on tetanus intoxication or the prophylactic and therapeutic actions of antitetanus serum. Other Soviet workers feel that autoinfection is overstressed, and that it is not really important in radiation disease. These investigators consider that the important basis for radiation diseases is the circulation of tissue disintegration products and a production of autoallergy. It is conceded, however, that the prevention of infectious disease is important after radiation sickness begins.

Most Soviet work on the interaction between irradiation and immunological responses demonstrates a decrease in immunity and a suppression of formation of antibodies, possibly through action of the central nervous system. A few Soviet investigators claim that ultraviolet, X- and gamma-irradiation in small doses provide stimulation of immunological processes. This needs confirmation and requires better control conditions than those provided. Soviet investigators feel that certain areas of study on the mechanism of action of radiation are susceptible to closer analysis using immunological techniques.

~~UNCLASSIFIED~~

APPENDIX A

RESEARCH INSTITUTES*

A. Khar'kov Institute of Medical Radiology
   Physicotechnical Division
   M. N. D'yachenko

B. Institute of Cytology and Genetics, Siberian Department, AS, USSR, Novosibirsk
   Director - N. P. Dubinin
   (also at the Institute of Biophysics, AS, USSR, Moscow)

C. Uzbek Scientific Research Institute of Blood Transfusion
   Director - A. T. Astanov
   S. D. Kalenova
   V. I. Kalugina
   G. S. Levin
   Z. G. Teplyakova
   A. Yu. Tilis

D. Institute of Internal Medicine, AMS, USSR
   Laboratory of Biophysics
   Head - M. N. Fateyeva
   N. I. Gorbarenko
   V. S. Klimov
   Ye. P. Stepanyan

E. Institute of Clinical and Experimental Surgery, AS, Kazakh SSR, Alma-Ata
   Director - A. N. Syzganov
   S. B. Balmukhanov

F. Institute of Physics, AS, USSR
   Radiation Genetics Laboratory
   M. A. Arseneva
   G. G. Tinyakov

G. Institute of Radiation Hygiene, Ministry of Health, RSFSR
   Director - F. G. Krotkov
   N. F. Galanin
   Yu. S. Belle
   A. N. Bragina
   V. N. Gus'kova
   V. M. Kupriyanova
   L. R. Romanov
   Ye. S. Romanova
   E. P. Storozhenko

H. Bashkir Medical Institute imeni 15th Anniversary of Komsomol, Ufa
   Chair of Pharmacology
   Head - D. N. Lazareva
   R. N. Abdullina
   A. Ya. Lagno

*The numbers are taken from "A Directory of Medical and Biological Research Institutes of the U.S.S.R.," U. S. Department of Health, Education, and Welfare, 1958. The letters are arbitrary.

I. The 14th Medical School
   Director - L. A. Bradman

J. Military Medical Service
   I. B. Beylin, Col.
   V. M. Burmistrov, Major
   N. V. Butomo, Major
   V. I. Filatov, Major
   L. A. Klyucharev, Lt. Col.
   A. N. Kornilov, Capt.
   L. S. Kreyin, Lt. Col.
   S. D. Kustanovich, Major
   I. A. Kuz'menko, Lt.
   V. F. Layne, Major
   M. K. Markaryan, Col.
   N. I. Matuzov, Major
   M. N. Nemkin, Lt. Col.
   B. L. Polyak, Col.
   Ya. G. Rubinshteyn, Lt. Col.
   V. I. Samtsov, Lt. Col.
   S. N. Sergenev, Major
   N. I. Shcherbakov, Lt.
   L. I. Shishlyannikova, Lt. Col.
   G. M. Tsygankov, Col.
   Ya. I. Veksler, Major
   Ye. G. Zhuk, Lt. Col.

K. Kuban Medical Institute imeni the Red Army, Krasnodar
   Department of Pathologic Physiology
   Director - I. A. Oyvin
   T. S. Barkagan
   Ye. Ye. Chebotarev

L. Experimental Laboratory of the North-Caucasus Military District
   Ya. I. Veksler (Rostov-on-the-Don)

M. Ukrainian Scientific Research Sanitary Chemical Institute, Kiev
   N. M. Binus
   M. B. Gintsburg
   Ye. M. Pandre

N. Institute of Biophysics, AMS, USSR, Moscow
   Director - A. V. Lebedinskiy
   P. D. Gorizontov
   B. M. Isayev
   N. A. Kurshakov
   M. N. Livanov
   V. A. Sanotskiy

O. Kazakh State Medical Institute imeni V. M. Molotov, Alma-Ata
   Director - I. S. Koryakin
   Chair of Roentgeno-Radiology
   S. B. Balmukhanov

P. Institute of Radiation and Physicochemical Biology, AS, USSR, Moscow
Director - V. A. Engel'gardt

Q. Scientific Research Institute of Medical Radiology, AMS, USSR, Moscow area
Director - (not yet named--new institute)
(1) Laboratory of Biophysics
(2) Laboratory of Medical Physics
(3) Laboratory of Microbiology
(4) Laboratory of Genetics
(5) Laboratory of Radiobiology

R. Odessa Pharmaceutical Institute
Director - A. G. Trotsenko
Chair of Biological Chemistry
V. A. Leshchinskiy
I. V. Savitskiy

S. Leningrad State University
Chair of Human and Animal Physiology
M. N. Maslova

40 Astrakhan State Medical Institute imeni A. V. Lunacharskiy, Astrakhan, RSFSR
Director - S. V. Zakharov
P. E. El'gort
N. P. Goncharenko
F. S. Karimova
I. V. Shvartser
T. A. Timofeyeva
(1) Department of Normal Physiology
Yu. N. Uspenskiy
(2) X-ray Department
K. G. Aslanov

57 Scientific Research Institute of Roentgenology, Radiology, and Oncology, Ministry of Health, Azerbaydzhan, SSR
Director - M. M. Alikishibekov
I. T. Abasov
Sh. M. Beybutov

113 Kalinin State Medical Institute, Kalinin, RSFSR
Director - R. I. Gavrilov
K. P. Ivanov
S. Ye. Manoylov

124 Kazan' Institute for Advanced Training of Physicians imeni V. I. Lenin
Director - L. M. Rakhlin
Clinic of Nervous Diseases
Head - I. I. Rusetskiy
U. Sh. Akhmerov

155 Ukrainian Research Institute for Orthopedics and Traumatology imeni M. I. Sitenko, Khar'kov, Ukrainian SSR
Director - N. P. Novachenko
A. A. Kravchenko

162 Institute of Biochemistry, AS, Ukrainian SSR, Kiev
Director - A. V. Palladin
O. P. Chepinoga
S. F. Epshteyn
I. Yu. Khilobok
M. A. Kolomiychenko

167 Institute of Physiology imeni A. A. Bogomolets, AS, Ukrainian SSR, Kiev
Former Director - A. F. Makarchenko
Present Director - A. M. Vorob'yev
N. M. Amdurskaya
A. I. Danilenko
R. Ye. Kavetskiy
R. D. Nikitenko
L. B. Stolyarova
1. Biophysics Laboratory (or Department)
Director - A. A. Gorodetskiy
Ye. Ye. Chebotarev
N. I. Kerova
O. A. Khomutovs'kiy
N. F. Lipkan
I. M. Shur'yan
N. D. Stetsenko
L. Ya. Zhoga
2. Laboratory of Circulatory and Respiratory Physiology
N. V. Il'chevich
V. A. Kozak
3. Laboratory of Endocrine Functions
T. K. Valuyeva
4. Laboratory of Morphology
Chief - A. I. Smirnova-Zamkova
T. N. Oleynikova
5. Laboratory of Compensatory and Defense Functions
Chief - R. Ye. Kavetskiy
Ye. M. Samundzhan

173 Scientific Research Institute of Neurosurgery, Ministry of Health, USSR, Kiev
Director - A. I. Arutyunov
(1) Department of Pathomorphology
Chief - B. S. Khominskiy
I. A. Brodskaya
(2) Department of Roentgenology
Chief - Ya. I. Geynisman
I. P. Merkulova

175 Kiev Institute for Advanced Training of Physicians, Ministry of Health, Ukrainian SSR
Director - I. P. Kal'chenko
O. A. Khomutovskiy

179 Kiev Institute of Labor Hygiene and Occupational Diseases, AMS, USSR, Kiev
Director - L. I. Medved'
M. A. Khvoynitskaya
G. G. Lysina
V. A. Mislenko

182 Kiev Scientific Research Roentgeno-Radiological and Oncological Institute, Ukrainian SSR
Director - I. T. Shevchenko
(1) Biochemical Laboratory
Head - N. M. Romanyuk
N. Ya. Dzyubko
(2) Laboratory of Experimental Cancer
Head - S. P. Sizenko
V. V. Markovich
(3) Laboratory of Radioactive Isotopes
Chief - R. Ye. Kavetskiy
Ye. P. Sidorik
Yu. A. Umanskiy

184 Kiev Medical Institute imeni A. A. Bogomolets, Kiev, Ukrainian SSR
Director - Ye. F. Shamray
(1) Chair of Pathological Anatomy
Chief - Ye. I. Chayka
V. G. Pinchuk
(2) Chair of Roentgenology and Radiology
Chief - N. F. Zarkevich
L. N. Triumfova
(3) Chair of Biochemistry
Chief - Ye. F. Shamray
L. N. Triumfova

216 Krasnoyarsk Medical Institute, RSFSR
Director - P. G. Podzolkov
Yu. M. Lubenskiy
I. A. Terskov
Chair of Hospital Surgery
Head - A. M. Dykhno
a. Laboratory of Biophysics
N. V. Gorbatyuk

225 Institute of Evolutionary Physiology imeni I. M. Sechenov, AS, USSR, Leningrad
Former Director - The late L. A. Orbeli
Present Director - A. G. Ginetsinskiy
Z. I. Barbashova
Z. V. Denisova
Laboratory of Histophysiology
Chief - Ye. A. Moiseyev
M. S. Konstantinova

226 Institute of Physiology imeni I. P. Pavlov, AS, USSR, Leningrad
Director - K. M. Bykov (Deceased 1959)
Laboratory of Physiology and Pathology of Higher Nervous Activity
Chief - F. P. Mayorov
N. Ya. Lipatova
B. V. Pavlov

236 Central Scientific Research Roentgenological, Radiological and Oncological Institute, Ministry of Health, USSR, Leningrad
Director - M. N. Pobedinskiy
Scientific Director - Yu. K. Kudritskiy
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V. F. Cherkasov
I. N. Davydova
I. V. Fedorova
L. A. Kachur
Ye. I. Komarov
O. G. Matveyev
A. Nevler
V. A. Petrov
A. B. Polezhayev
Ye. A. Prokudina
A. M. Rusanov
L. F. Semenov
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K. B. Skvirskaya
S. V. Strutsovskaya
Ye. V. Utekhin
(1) Department of Radiosurgery
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A. I. Strashinin
(2) Department of Pathological Anatomy
Head - L. V. Funshteyn
E. I. Shcherban'
Laboratory of Pathological Anatomy
Director - L. V. Funshteyn
L. A. Cherkasskiy
(3) Department of Experimental and Pathological Morphology
Head - G. S. Strelin
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A. D. Pushnitsyna
Laboratory of Experimental Morphology
Director - G. S. Strelin
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(6) Biochemistry Department
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L. V. Mytareva
A. S. Orlov
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(7) Second Diagnostic Cabinet
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238 Institute of Experimental Medicine, AMS, Leningrad
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240 Institute of Obstetrics and Gynecology, AMS, USSR, Leningrad
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N. M. Andriyasheva
(2) Biochemical Laboratory
Head - A. D. Braun
Z. N. Zhakhova

241 Institute of Oncology, AMS, USSR, Leningrad
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(1) Gynecological Department
Head - A. I. Serebrov
M. B. Golubitskaya
(2) Laboratory of Experimental Oncology
Head - L. M. Shabad
S. N. Ardashnikov
Ye. L. Prigozhina
I. G. Spasskaya

249 Leningrad Scientific Research Institute of Hematology and Blood Transfusion
Directors - A. D. Belyakov and A. Ye. Kiselev
Scientific Director - A. N. Filatov
Biochemistry Laboratory
Former chief - N. N. Blokhin
I. S. Luganova
L. S. Rotfel'd

250 Leningrad Scientific Research Institute of Labor Hygiene and Occupational
Diseases, Ministry of Health, RSFSR, Leningrad
Director - Z. E. Grigor'yev
N. K. Bakhusov
I. D. Makulova

264 First Leningrad Medical Institute imeni I. P. Pavlov Ministry of
Health, RSFSR
Director - A. I. Ivanov
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T. N. Tuzhilkova
L. Ya. Zhorno
(2) Chair of Normal Physiology
Chief - A. I. Naumenko
N. N. Vasilevskiy

268 Leningrad Order of Lenin State Institute for Advanced Training of
Physicians imeni S. M. Kirov
Director - N. I. Blinov
(1) Chair of Medical Radiology
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M. Ya. Kozlov
S. S. Sokolov
V. N. Vorob'yev
A. G. Zemlyanov
(2) Third Surgical Clinic
Head - N. I. Blinov
S. S. Sokolov
V. I. Trubachev
V. N. Vorob'yev
A. G. Zemlyanov
(3) Pathology Department
Head - P. V. Sipovskiy
Z. A. Vlasova

270 Leningrad State Scientific Research Institute of Eye Diseases imeni
L. L. Girshman, Leningrad
Director - B. P. Kalashnikov

274 Leningrad State Pediatric Medical Institute, Ministry of Health, RSFSR,
Leningrad
Director - N. T. Shutova
(1) Department of Biochemistry
I. I. Ivanov
M. M. Stepanova
(2) Department of Pharmacology
Chief - V. M. Karasik
A. M. Rusanov

278 Main Military Hospital imeni N. N. Burdenko, Ministry of Defense, Leningrad
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Present Director - N. N. Nevskiy
P. V. Kinonov
V. K. Polenko
P. V. Simonov
A. A. Zhgun
(1) Radiotherapy Department
Head - A. N. Gamaleya
V. D. Arutyunov
(2) Experimental Laboratory
Head - A. A. Gyurdzhiyan

280 Military Medical Order of Lenin Academy imeni S. M. Kirov, Leningrad
Director - P. P. Goncharov
Scientific Director - M. S. Maslov
Ye. G. Zhuk, Lt. Col., Medical Service
(1) Department of Pharmacology
(2) Chair of Normal Anatomy
I. D. Lev
(3) Laboratory of Nutrition - A. N. Liberman
(4) Clinic of Military Field Surgery
Chief - A. N. Berkutov
Chzhu Chzhun Lin
G. T. Golikov

326 Institute of Animal Morphology imeni A. N. Severtsov, AS, USSR, Moscow
Director - G. K. Khrushchev
B. L. Astaurov
V. Ya. Brodskiy
T. A. Detlaf
Z. N. Faleyeva
E. Ya Grayevskiy
A. F. Ivanitskaya (Ivanitsova)
M. M. Konstantinova
L. I. Korchak
A. A. Neyfakh
I. M. Shapiro
M. I. Sorokina
I. A. Suyetina
N. M. Tul'tseva
T. M. Turpayev

327 Institute of Biochemistry imeni A. N. Bakh, AS, USSR, Moscow
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V. P. Blokhina
G. A. Deborin
A. G. Pasynskiy
N. M. Sisakyan
M. S. Volkova

328 Institute of Biophysics, AS, USSR, Moscow
  Director - G. M. Frank
    N. A. Aladzhalova
    V. M. Alekseyeva
    O. G. Arakelov
    M. L. Belgovskiy
    V. N. Benevolenskiy
    A. V. Bibergal'
    L. P. Breslavets
    Ye. V. Budilova
    N. P. Dubinin (see institute B)
    L. Kh. Eydus
    N. A. Gabelova
    Ye. A. Ganassi
    M. M. Gromakovskaya
    Ye. A. Ivanitskaya
    M. B. Kalamkarova
    O. L. Kanavetz
    L. P. Kayushin
    L. L. Khamaide
    V. V. Khvostova
    N. V. Kondakova
    M. M. Korotkov
    B. K. Lemazhikhin
    L. B. Levinson
    Ya. A. Liberman
    N. N. Livshits
    Ya. V. Mamul'
    U. Ya. Margulis
    M. N. Meysel'
    P. F. Minayev
    G. V. Nizhnik
    G. K. Otarova
    N. V. Pankova
    V. I. Plokhoy
    Ye. G. Plyshevskaya
    A. I. Polivoda
    S. Ye. Rapoport
    A. L. Shabadash
    D. M. Shifrin
    L. S. Shtern
    V. N. Sidorov
    A. A. Slepov
    A. D. Snezhko
    M. V. Sokolov
    V. A. Sondak
    N. B. Strazhevskaya
    E. N. Tolkacheva
    K. S. Trincher
    K. I. Zhuravlev
    S. R. Zubkova
      (1) Radiobiology Laboratory
        Head - A. M. Kuzin
          E. N. Kolody
          N. I. Shapiro

(2) Laboratory of the Biophysics of Radiation
Ya. L. Shekhtman
K. N. Yemel'yanov

331 Institute of Genetics, AS, USSR, Moscow
Director - T. D. Lysenko
I. Ye. Glushchenko
Kh. F. Kushner
N. N. Kuznetsova
M. D. Pomerantseva
K. S. Sukhov
Cytology Laboratory
O. P. Domareva
O. N. Kitayeva
I. A. Nechayev
N. I. Nuzhdin
O. N. Petrova
M. V. Volkovich

332 Institute of Higher Nervous Activity, AS, USSR, Moscow
Former Director - A. G. Ivanov-Smolenskiy
Present Director - V. S. Rusinov
Assistant Director - I. V. Strel'chuk
K. I. Pogodayev
(1) Radiobiology Laboratory
I. A. Piontkovskiy
(2) Laboratory of Vegetative Conditional Reflexes
Chief - A. A. Pavlovskaya
L. N. Khruleva

333 Institute of Microbiology, AS, USSR, Moscow
Director - A. A. Imshenetskiy
Deputy Director - N. D. Yerusalimskiy
A. M. Pasechnik
L. A. Seliverstova
(1) Division of Development and Variability of Microorganisms
Head - A. A. Imshenetskiy
(2) Division of Agricultural and Soil Microbiology
Head - Ye. N. Mishustin
(3) Division of Geomicrobiology
Head - S. I. Kuznetsov
V. A. Ekzertsev
L. D. Shturm
(4) Division of Taxonomy
Head - N. A. Krasil'nikov
(5) Division of Experimental Morphology and Cytology
Head - M. N. Meysel'

334 State Institute of Natural Sciences imeni P. F. Lesgraft, AS, USSR, Moscow
Director - A. M. Samarin
M. A. Khenokh
E. M. Lapinskaya

357 All-Union Scientific Research Institute of Antibiotics, Ministry of Health, USSR, Moscow
Director - M. A. Guberniyev
S. I. Alikhanyan

361 All-Union Institute of Experimental Endocrinology, Moscow
Director - Ye. A. Vasyukova
K. A. Tret'yakova
(1) Department of Morphology
Chief - Ye. I. Tarakanov
Ye. B. Pavlova
(2) Radiation Laboratory
Chief - D. E. Grodzenskiy
A. Ye. Rabkina

366 All-Union Scientific Research Institute of Medicinal and Aromatic Plants, Ministry of Health, USSR, Moscow
Director - N. Ya. Itskov
Ya. A. Aleshkina
B. K. Rostotskiy

384 Moscow Central Institute for Advanced Training of Physicians, Ministry of Health, USSR
Director - V. P. Lebedeva
N. A. Krayevskiy
N. N. Litvinov
R. I. Makarycheva
(1) Department of Radiation Disease
Chief - A. V. Kozlova
L. M. Omel'yanenko
(2) Chair of Radiation Hygiene
Chief - F. G. Krotkov
V. A. Arkayev
A. V. Terman
(3) Military Chair
V. A. Arkayev
(4) Second Department of Roentgenology and Radiology
Chief - Yu. N. Sokolov
L. N. Mushina-Udgodskaya
L. N. Udgodskaya
Yu. G. Yudin
(5) First Chair of Roentgenology and Radiology
Chief - S. A. Reynberg
(6) Chair of Medical Radiology
Chief - V. K. Modestov
S. Ye. Shnol'

392 Central Order of Lenin Institute of Hematology and Blood Transfusion, Moscow, Ministry of Health, USSR
Director - A. A. Bagdasarov
G. M. Abdulayev
V. A. Agranenko
O. V. Aksenova
B. F. Beliyayeva
M. P. Bogoyavlenskaya
G. M. Boldysheva
N. Ye. Lagutina
N. V. Nikolayeva
R. I. Rodina
L. S. Rogacheva
Ye. V. Shamshina
L. L. Shepshelevich
M. G. Shitikova
S. B. Skopina
S. V. Skurkovich
F. R. Vinograd-Finkel'
1. Radiobiology Laboratory
Head - M. O. Raushenbakh
I. B. Gurevich

398 Moscow Scientific Research Institute of Sanitation and Hygiene imeni F. F. Erisman, Ministry of Health, RSFSR
Director - A. Z. Belousov
L. B. Dolivo-Dobrovol'skiy
M. G. Durmish'yan
V. P. Godin
V. G. Golubev
S. I. Gorshkov
V. I. Kondror
G. A. Malov
Yu. V. Novikov
V. F. Oreshko
M. A. Pinigan
B. A. Polivoda
Ye. N. Ryumina
V. M. Zakharov
F. S. Zavel'skiy
L. V. Zhidkova
(1) Division of Radiology
S. I. Gorshkov
(2) Division of Hygiene
N. N. Khvostov

399 Central Institute of Traumatology and Orthopedics, Ministry of Health, USSR, Moscow
Director - N. N. Priorov
Laboratory of Biochemistry
Chief - B. S. Kasavina
Ye. B. Spektor

406 Institute of Biological and Medical Chemistry, AMS, USSR, Moscow
Director - V. N. Orekhovich
T. Grunt
Ye. M. Kedrova
L. V. Orlova
V. P. Polyakov
V. M. Rodionov
V. D. Uspenskaya
O. G. Zamyatkina
1. Laboratory of Physiological Chemistry
N. K. Lebedeva

408 Institute of Epidemiology and Microbiology imeni N. F. Gamaleya, AMS, USSR, Moscow
Former Director - G. V. Vygodchikov
Present Director - S. N. Muromtsev
Deputy Production Director - Stepanchenok
1. Department of Medical Microbiology
Chief - V. L. Troitskiy
A. P. Duplishcheva
M. A. Tumanyan
A. V. Izvekova
L. A. Zil'ber
V. A. Artamonova

410 Institute of Experimental and Clinical Oncology, AMS, USSR, Moscow
Director - N. N. Blokhin

414 Institute of Labor Hygiene and Occupational Diseases, AMS, USSR, Moscow
Director - A. A. Letavet
A. S. Arkhipov
G. A. Avrunina
E. F. Baranova
N. L. Beloborodova
E. A. Bodrovaya
L. N. Burykina
N. K. Byalko
E. A. Drogichina
I. A. Gelfon
I. N. Golovnikova
S. M. Gorodinskiy
Ye. D. Grishchenko
N. G. Gusev
N. I. Ivanov
M. A. Kazakevich
T. A. Kochetkova
E. B. Kurlyandskaya
V. S. Kushneva
M. S. Lapteva-Popova
T. B. Linevich
A. N. Marey

V. V. Nikitenko
V. G. Osipova
G. M. Parkhomenko
Ye. K. Red'kina
A. A. Rubanovskaya
M. N. Ryzhkova
A. O. Saytanov
Ye. A. Solov'yeva
V. I. Stepanova
N. Yu. Tarasenko
L. G. Tsenterova
V. F. Ushakova
N. V. Vershinin
N. I. Vinogradova
N. I. Volkova
(1) Section of Labor Hygiene
Chief - L. K. Arkhipov
(2) Clinic
a. Radiologic Section
Chief - M. N. Toleyva
b. X-Ray Diagnostic Section
Chief - K. P. Molokanov

422 Institute of Normal and Pathological Physiology, AMS, USSR, Moscow
Director - V. N. Chernigovskiy
Deputy (Scientific) Director - A. A. Volokov
(1) Laboratory of Infectious Pathology
Chief - A. Ya. Alimov
G. N. Kryzhanovskiy
(2) Laboratory of Radiobiology
Chief - N. N. Lebedev

423 Institute of Nutrition, AMS, USSR, Moscow
Director - O. P. Molchanova
Radiobiology Laboratory
Chief - G. P. Yeremin
Consultant - G. K. Shlygin
M. F. Nesterin

424 Institute of Obstetrics and Gynecology, Ministry of Health, RSFSR, Moscow
Director - L. G. Stepanov
Laboratory of Pathomorphology
Chief - Ye. N. Petrova
M. N. Kuznetsova

427 Institute of Pediatrics, AMS, Moscow
Director - O. D. Sokolova-Ponomareva
(1) Radiobiology Laboratory
Head - L. A. Shparo
T. V. Fokina
T. D. Mirimova

(2) Department of Development of the Brain
Chief - B. N. Klosovskiy
Yu. I. Barashnev
Ye. N. Kosmarskaya

428 Institute of Pharmacology, Experimental Chemotherapy, and Chemoprophylaxis, AMS, USSR, Moscow. (Also known as: Institute of Pharmacology and Chemotherapy)
Director - V. V. Zakusov
G. Ya. Kivman
1. Laboratory of Specific Pharmacology
Head - V. V. Zakusov
G. S. Koroza

429 State Scientific Research Institute of Physiotherapy, Ministry of Health, USSR, Moscow
Director - A. N. Obrosov
M. E. Manikov
Ye. I. Rozenblit

431 Scientific Research Institute of Psychiatry, Ministry of Health, USSR, Moscow
Director - D. D. Fedotov
Department of Neurology
Chief - I. K. Zyuzin
T. S. Zaychkina

433 Institute of Therapy, AMS, USSR, Moscow
Director - A. L. Myasnikov
Ye. V. Erina
N. I. Gorbarenko
V. S. Klimov
V. Ye. Ostapkovich
E. P. Stepanyan
Biophysics Laboratory
Head - M. N. Fateyeva
Ye. A. Denisova

436 Moscow Oblast Scientific Research Clinical Institute imeni M. F. Vladimirskiy, Moscow, USSR
Director - P. M. Leonenko
Department of Pathomorphology
Chief - S. B. Vaynberg
Yu. G. Yudin

452 First Moscow Order of Lenin Medical Institute imeni I. M. Sechenov, Moscow
Director - V. Kovanov
G. A. Avrunina
N. G. Darenskaya
M. P. Domshlak
Yu. G. Grigor'yev
M. N. Livanov

(1) Department of General Hygiene
V. Ya. Golikov
I. I. Gusarov

(2) Department of Skin and Venereal Diseases
Head - V. A. Rakhmanov
V. S. Minasov

(3) Faculty Therapeutic Clinic
Chief, - V. N. Vinogradov
A. L. Syrkin

454 Moscow Medical Stomatological Institute, Ministry of Health, RSFSR, Moscow
Director - G. N. Beletskiy
Department of Roentgenology and Radiology
Director - N. A. Shekhter
N. A. Zhizhina

457 Moscow State University imeni M. V. Lomonosov
President - I. G. Petrovskiy
L. B. Levinson
N. V. Pankova
G. G. Polikarpov
N. I. Shapiro
(1) Physiopathology Institute
O. V. Popov
(2) Faculty of Agricultural Biology
E. G. Lomovskaya
Ye. I. Vorob'yeva
(3) Department of Animal Biochemistry
Chairman - B. A. Kudriashov
A. V. Golubtsova
E. V. Moiseyenko
M. I. Safronova
(4) Department of Biochemistry
G. V. Andreyenko
G. G. Bazaz'yan
M. V. Kirzon
M. G. Pshennikova
(5) Department of Genetics
S. I. Isayev
(6) Department of Biophysics
Chief - B. N. Tarusov
E. S. Elkhovska
K. D. Kalantarov
V. G. Khonazuk
V. I. Korogodin
Yu. A. Kriger
A. S. Molchalina
I. A. Motuzova
G. V. Sumarukov
(7) Chair of Histology
N. V. Belitsina
Ye. S. Kirpichnikova
L. V. Ol'shevskaya

467 State Institute of Oncology imeni P. A. Gertsen, Moscow
Director - A. N. Novikov
(1) Department of X-Ray Diagnosis
(2) Department of Clinical and Experimental Anesthesiology
(3) Department of Virology
(4) Department of Histopathology
(5) Division of Radiation Therapy
(6) Department of Roentgenology

470 State Scientific Research Institute of Roentgenology and Radiology imeni V. M. Molotov, Ministry of Health, RSFSR, Moscow
Director - I. G. Lagunova
V. V. Dmokhovskiy
K. M. Malenkova
V. S. Matov
D. S. Mitskevich
(1) Organization and Methodology Section
Chief - V. P. Vikturin
A. V. Frolova
I. Ye. Pasynkova
T. S. Seletskaya
E. Ye. Troitskiy
(2) Radiology Department
Chief - A. V. Kozlova
A. P. Belousov
M. Ya. Chaykovskaya
N. N. Garvey
I. S. Kas'yanov
A. A. Klimenko
N. P. Mordvinova
A. I. Morozov
A. Z. Nagrodskaya
O. S. Sergel'
A. V. Shubina
I. B. Tsybul'skiy
G. N. Yelapt'yeva
M. P. Yeleazarova
G. A. Zubovskiy
Ye. A. Zuykova
(3) Roentgenotherapeutic Department
Chief - L. D. Podlyashchuk
A. I. Ruderman
V. B. Zayrat'yants
L. M. Sherman
(4) Pathomorphological Department
Chief - B. N. Mogil'nitskiy
(5) Department of Experimental Pathology
Chief - V. P. Shekhonin
V. B. Zayrat'yants

487 Odessa Scientific Research Institute of Dermatology and Venereal Diseases imeni Ye. S. Glavche, Odessa, Ukrainian SSR
Director - S. I. Matuskov

1. Department of Dermatology
   Chief - G. I. Landa
   A. M. Kharchenko
   I. N. Vinokurov

494 Odessa Medical Institute, Ministry of Health, Ukrainian SSR
Director - A. N. Motenko
(1) Chair of Roentgenology and Radiology
Head - Ye. D. Dubovyy
D. Baldandozh
K. G. Tagibekov
(2) Chair of Pharmacology
Head - S. V. Tsyganov
(3) Propadeutic Surgical Clinic
Head - I. Ya. Deyneka
K. G. Tagibekov

498 Ukrainian Experimental Institute of Eye Diseases and Tissue Therapy imeni V. P. Filatov, Odessa
Former Director - V. P. Filatov, deceased 1956
Present Director - N. A. Puchkovskaya
I. F. Kovalev

554 Biological Research Station imeni A. O. Kavalevskiy, AS, USSR, Sevastopol', Crimea, RSFSR
Director - V. A. Vodyanitskiy
G. G. Polikarpov

561 Smolensk Medical Institute, Smolensk, RSFSR
Director - G. M. Starikov
V. A. Shkapina

571 Stalinabad Medical Institute imeni Abuali Ibn Sino (Avicenna), Stalinabad, Tadzhik SSR
Director - Kh. D. Gadzhiyev
Kh. Kasymov

589 Institute of Experimental Pathology and Therapy, Sukhumi
Director - I. A. Utkin
Scientific Director - B. A. Lapin
1. Laboratory of Radiology
L. F. Semenov

591 Institute of Biology, Ural Affiliate, AS, USSR, Sverdlovsk
Director - N. V. Timofeyev-Resovskiy
V. G. Kulikova
N. V. Luchnik
E. A. Timofeyeva-Resovskaya

596 Sverdlovsk Institute of Labor Hygiene and Occupational Diseases, RSFSR
- R. V. Bessarobova
- T. I. Kazantseva
- V. A. Mikhaylova
- I. Ye. Okonishnikova
- G. A. Prokopenko
- A. A. Yudeles
  1. Laboratory of Radiobiology
     - O. I. Komarova

666 Tomsk Medical Institute, RSFSR
Director - S. P. Khodkevich
- (1) Chair of Surgery of the Sanitation Faculty
  Head - K. N. Cherepnin
  V. N. Agafonova
- (2) Chair of Pathological Anatomy
  Head - I. V. Toroptsev
  N. V. Sokolova

702 Voronezh Roentgeno-Radiological and Oncological Institute, RSFSR
Director - M. P. Abakumov
- I. I. Grigor'yev (Sochi)

720 Institute of Physiology, Armenian AS, Yerevan
Radiobiology Laboratory
- T. T. Adunts
- Ts. M. Avakyan
- G. G. Demirchoglyan
- A. B. Tsypin
- V. A. Tumanyan

726 Scientific Research Institute of Blood Transfusion, Ministry of Health, Armenian SSR
Director - R. O. Yeolyan
- S. N. Allaverdyan
- I. A. Yerzinkyan (Possibly in institute 729)

729 Scientific Research Institute of Roentgenology and Oncology, Ministry of Health, Armenian SSR, Yerevan
Director - V. A. Fanardzhyan
- R. K. Arutyunyan
- A. G. Beglaryan
- I. G. Demirchoglyan
- K. A. Kyandaryan
- M. A. Movsesyan
- S. A. Papoyan
- S. G. Shukutyan
- I. A. Yerzinkyan (see institute 726)
- A. A. Zagatskaya

APPENDIX B

RESEARCH PERSONNEL

[The numbers are keyed to the institutes listed in appendix A.]

ABASOV, I. T. - 57
ABDULAYEV, G. M. - 392
ABDULAYEV, M. D.
ABDULLINA, G. Z.
ABDULLINA, R. N. - H
ABGAROV, V. I.
ADUNTS, G. I.
ADUNTS, T. T. - 720
AGAFONOVA, V. N. - 666
AGARKOV, F. T.
AGLINTSEV, K. K.
AGRANAT, V. Z.
AGRANENKO, V. A. - 392
AKHMEROV, N. Sh. -124
AKSENOVA, O. V. - 392
ALADZHALOVA, N. A. - 328
ALEKSANDROV, S. N. - 326
ALEKSANDROVA, M. F.
ALEKSANDROVSKAYA, M. M.
ALEKSIYEVA, V. M. - 328
ALESHKINA, Ya. A. - 366
ALIKHANYAN, S. I. - 357
ALLAVERDYAN, S. N. - 726
AMIRAGOVA, M. G.
AMOSOV, I. S.
ANDREYENKO, G. V. - 457
ANDREYEVA, O. S.
ANDREYEVA, Ye. I.
ANDRIYASHEVA, N. M.-240
AMDURSKAYA, N. M. - 167
ANTONOV, A. A. - 238
ARAKELOV, O. G. - 328
ARBUZOV, S. Ya.
ARDASHNIKOV, S. N. - 241
ARKAYEV, V. A. - 384
ARKHIPOV, A. S. - 414
ARKHIPOV, L. K. - 414
ARLASHCHENKO, N. I.
ARSEN'YEVA, M. A. - F
ARTAMONOVA, V. A. - 408
ARTYUKHINA, N. I.
ARUTYUNOV, V. D. - 278
ARUTYUNYAN, R. K. - 729
ASLANOV, K. G. - 40
ASTAUROV, B. L. - 326

AVAKYAN, Ts. M. - 720
AVRUNINA, G. A. - 414, 452
AYRAPETYANTS, M. G.
AZERBAIDZHAN, M. M. - 57

BAGRAMYAN, E. R.
BAKHUSOV, N. K. - 250
BALABUKHA, V. S.
BALASHKO, Yu. G.
BALASHOVA, A. N.
BALDANDOZH, D. - 494
BAIMUKHANOV, S. B. - E, O
BARAKINA, N. F.
BARANOVA, E. F. - 414
BARASHNEV, Yu. I. - 427
BARBASHOVA, Z. I. - 225
BARKAGAN, T. S. - K
BAVRO, G. V.
BAZAZ'YAN, G. G. - 457
BEGLARYAN, A. G. - 729
BELEN'KAYA, S. Ye.
BELGOVSKIY, M. L. - 328
BELITSINA, N. V. - 457
BELITSKIY, A. S.
BELIYAYEVA, B. F. - 392
BELLE, Ya. S. - G
BELOBORODOVA, N. L. - 414
BELOUSOV, A. P. - 470
BELOUSOV, A. Z. - 398
BELOUSOVA, O. I.
BELYAYEVA, B. F. - 392
BENEVOLENSKIY, V. N. - 328
BENTSIANOVA, V. M.
BERKUTOV, A. N. - 280
BERKUTOVA, I. D.
BESSAROBOVA, R. V. - 596
BEYBUTOV, Sh. M. - 57
BEYLIN, I. B. - J
BIBERGAL', A. V. - 328
BINUS, N. M. - M
BIRYUKOV, D. A. - 238
BLINOV, V. A.
BLOKHIN, N. N. - 249, 410
BLOKHINA, V. D.

BLOKHINA, V. P. - 327
BOBKOV, A. I.
BOCHKAREV, V.
BODROVAYA, E. A. - 414
BOGOMOLETS, O. A.
BOGOYAVLENSKAYA, M. P.-392
BOLDYSHEVA, G. M. - 392
BORISOV, Ye. V.
BORISOVA, I. G.
BOVIN, V. V.
BRADMAN, L. A. - I
BRAGINA, A. N. - G
BRAUN, A. D. - 240
BRESLAVETS, L. P. - 328
BRODSKAYA, I. A. - 173
BRODSKIY, V. Ya. - 326
BRUMSHTEYN, V. N.
BRYUKHANOV, O. A.
BUDILOVA, Ye. V. - 328
BUDKO, L. M.
BUDNITSKAYA, Ye. V.
BUKHTOYAROVA, Z. M.
BURLAKOVA, E. V.
BURMISTROV, V. M. - J
BURYKINA, L. N. - 414
BUTOMO, N. V. - J
BUZINI, P. A. - 236
BYALKO, N. K. - 414
BYCHKOVSKAYA, I. B. - 236

CHAREULI, Ye. I.
CHAYKOVSKAYA, M. Ya. -470
CHEBOTAREV, K. Ye.
CHEBOTAREV, Ye.Ye.-10,-167
CHEPINOGA, O. P. - 162
CHEREPNIN, K. N. - 666
CHERKASOV, V. F. - 236
CHERKASSKIY, L. A. - 236
CHERNICHENKO, V. A.
CHESNOKOVA, A. P.
CHOCHIYA, K. N. - 236
CHUBAKOV, A. A.
CHUCHUKALO, A. I.
CHZHU CHZHUN LIN - 280

MAKARYCHEVA, R. I. - 384
MAKULOVA, I. D. - 250
MALENKOVA, K. M. - 470
MALOV, G. A. - 398
MAMAMTAVRISHVILI, D. G.
MAMUL', Ya. V. - 328
MANIKOV, M. E. - 429
MANOYLOV, S. Ye. - 236-113
MARCHUK, R. Ya.
MAREY, A. N. - 414
MARGULIS, U. Ya. - 328
MARKARYAN, M. K. - J
MARKOVICH, V. V. - 182
MASLOVA, M. N. - S
MATOV, V. S. - 470
MATUZOV, N. I. - J
MATVEYEV, O. G. - 236
MAYOROV, F. P. - 226
MAYZEROV, Ye. S.
MEDNIK, M. R.
MEL'NICHENKO, A. V.
MERKULOV, A. I.
MERKULOVA, I. P. - 173
METER, I. D.
MEYSEL, M. N. - 333-328
MIKHAYLOVA, N. G.
MIKHAYLOVA, V. A. - 596
MIKHAYLOVICH, Boris
MIKHAYLOVICH, S. M.
MIKLASHEVSKIY, V. Ye.
MINASOV, V. S. - 452
MINAYEV, P. F. - 328
MIRIMOVA, T. D. - 427
MIR'SALIMOV, M. M.
MISHUSTIN, Ye. N. - 333
MISLENKO, V. A. - 179
MITSKEVICH, D. S. - 470
MODESTOV, V. K.
MOGIL'NITSKIY, B. N. - 470
MOISEYENKO, E. V. - 457
MOISEYEV, Ye. A.
MOLCHALINA, A. S. - 457
MOLOKANOV, K. P. - 414
MORDVINOVA, N. P. - 470
MORGUN, Ye. G.
MOROZOV, A. I. - 470
MOROZOV, B. B.
MOSHARIV, A. I.
MOSKALEV, Yu. I.
MOTUZOVA, I. A. - 457
MOVSESYAN, M. A. - 729
MUSHINA-UDGODSKAYA, L. N.-384

MURAT, V. N.
MYTAREVA, L. V. - 236

NAGRODSKAYA, A. Z. - 470
NAVASHIN, M. S.
NAZARISHVILI, G. P.
NAZAROV, V. A.
NECHAYEV, I. A. - 331
NEMKIN, M. N. - J
NEMTSOVA, O. L.
NESTERIN, M. F. - 423
NEVLER, A. - 236
NEVSKAYA, G. F.
NEYFAKH, A. A. - 326
NIKITENKO, R. D. - 167
NIKITENKO, V. V. - 414
NIKITINA, K. I. - 236
NIKOLAYEVA, N. V. - 392
NIZHNIK, G. V. - 328
NOVIKOV, Yu. V. - 398
NOVIKOVA, A. P.
NUZHDIN, N. I. - 331

OGANESYAN, A. A. - 729
OKONISHNIKOVA, I. Ye.-596
OKULOV, N. M. - 236
OLEYNIKOVA, T. N. - 167
OL'SHEVSKAYA, L. V. - 457
OMEL'YANENKO, L. M. - 384
ORESHKO, V. F. - 398
ORLOV, A. S. - 236
ORLOVA, L. V. - 406
OSIPOV, Ye.
OSIPOVA, V. G. - 414
OSTAPKOVICH, V. Ye. - 433
OTAROVA, G. K. - 328
OYVIN, I. A. - K

PALLADIN, A. V. -162
PANDRE, Ye. M. - M
PANKOVA, N. V. - 328-457
PAPOYAN, S. A. - 729
PARKHOMENKO, G. M. - 414
PASECHNIK, A. M. - 333
PASYNKOVA, I. Ye. - 470
PASYNSKIY, A. G. - 327
PAVLOV, B. V. - 226
PAVLOVA, Ye. B. - 361
PAVLOVSKAYA, T. Ye.

PERUMOVA, N. D.
PETERSON, O. P.
PETROV, R. V.
PETROV, V. A. - 236
PETROVA, A. S.
PETROVA, O. N. - 331
PETROVICH, I. K.
PETROVSKY, I. G. - 457
PIGALEV, I. A.
PINCHUK, V. G. - 184
PINIGAN, M. A. - 398
PINUS, A. A.
PIONTKOVSKIY, I. A. - 332
PITSKHELAURI, G. Z.
PLOKHOY, V. I. - 328
PLYSHEVSKAYA, Ye. G. - 328
POBEDINSKIY, M. N.-~~268~~236
PODLYASHCHUK, L. D. - 470
POGODAYEV, K. I. - 332
POLENKO, V. K. - 278
POLEZHAYEV, A. B. - 236
POLIKARPOV, G. G.-457-554
POLIVODA, A. I. - 328
POLIVODA, B. I. - 398
POLUBOYARINOVA, E. I.
POLYAK, B. L. - J
POLYAKOV, V. P. - 406
POMERANTSEVA, M. D. - 331
PONOMARENKO, N. Ye. - 236
PONOMARKOV, V. I.
POPEL', L. V.
POPLAVSKIY, N. K. - 236
POPOV, O. V. - 457
POSHERSTNIK, S. Yu.
PRIGOZHINA, Ye. L. - 241
PROKOFEYEVA-BELGOVSKAYA, A.A.
PROKOPENKO, G. A. - 596
PROKUDINA, Ye. A. - 236
PRUSHIN, Ya.
PSHENNIKOVA, M. G. - 457
PUSHNITSYNA, A. D. - 236

RABINOVICH, R. M.
RABKINA, A. Ye. - 361
RAKHMANOV, V. A. - 452
RAPOPORT, I. A.
RAPOPORT, S. Ye. - 328
RAUSHENBAKH, M. O. - 392
RAVDONIK, K. S.
RAZGOVOROV, B. L.
RED'KINA, Ye. K. - 414

APPENDIX C

SUBSTANCES INVESTIGATED FOR PROPHYLACTIC EFFECT AGAINST IRRADIATION

fat
crocus
thiourea
tyramine
cysteine
ephedrine
phenatine
glutathione
unithiol
adrenaline
thiophenatine
propylphenamine
antianemin
properdin
phthivazide
cysteineamine
cystineamine
cysteineamine chloride
cysteineamine ascorbate
cysteineamine nicotinate
cysteineamine salicylate
N-acetylcysteineamine
triacetylcysteineamine
tetramethylcystineamine
tetraethylcystineamine
B-B-dimercaptoethylamine
chondroitin sulfate
5-oxy-4-methyl-uracil
5-amino-4-methyl-uracil
5-amino-4-methyl-cytosine
adrenocorticotropic hormone (ACTH)
yeast
uracil
validol
kampolon
phenamine
synestrol
cobalt salts
acetylcholine
methylphenatine
methylthiourea
phenylethylamine
methoxytyramine
diethylstilbestrol
beta-cytosterol
amino-mercaptocaproic acid
mercaptocaproic acid
methylphenatine
phenylphenamine
para-aminobenzoldisulfide
B-mercaptoethyldiethylamine
sodium chlorophyllin
cholinolytic agents
isothiouronic derivatives
pyrogallol derivatives
thiodiazole derivatives
para-aminobenzoic acid (PABA)
mercapto-caffein-ethylamine
zymosan (a yeast extract)
dithiocarbamino-acid-ammonia
somatotropic hormone (STH)
chlorpromazine ("aminazine")

2-6-diamino-5-nitro-4-methyl-pyrimidine
antireticulocytotoxic serum of Bogomolets (ACS)
vitamins (A, B_1, B_6, B_{12}, C, folic acid, niacin)
S-2-B-aminoethylisothiouronium bromide hydrobromide (AET)
preparation-88 (1,6-hexamethylenebistrimethyl ammonium iodide)
anikhain (piperidylethanol diphenylacetate hydrochloride)
para-aminopropiophenone and derivatives
preserved tissue (therapy by Filatov method of biogenic stimulators)
hyaluronic acid (and its protein complexes)
pentoxyl (2,6-dihydroxy-4-methyl-5-hydroxymethylpyrimidine)
metacyl (2,6-dihydroxy-4-methyl-pyrimidine)
preparation-96 (bis-β-diethylaminoethylester of mesodiphenylsuccinic acid dihydrochloride)
sodium nucleinate (sodium salt of purified nucleic acids obtained by hydrolysis of yeast)
leucogen [2-α-phenyl-α-carbethoxymethyl)-thiazolidine-4-carboxylic acid]
Tezan-25 (pyrimidine derivative of unknown structure)

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